CERES Cloud Properties: Update Fall 2015

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Thanks to Dave Doelling and his calibration team!

Topics

- Publications
- Status
- Cautions & Validation

- Trends and Variations
- GEO clouds
- Enhanced C3M Cloud Properties

Update of CERES Cloud-related Papers since May 2015

Edition-2 related

Wang, S., A. H. Sobel, A. Fridlind, Z. Feng, J. Comstock, P. Minnis, and M. L. Nordeen, 2015: Simulations of cloud-radiation interaction using large-scale forcing derived from the CINDY/DYNAMO northern sounding array. *J. Adv. Model. Earth Syst.*, submitted.

Edition-4+ related

Painemal, D., P. Minnis, and M. L. Nordeen, 2015: Aerosol variability, synoptic-scale processes and their link to the cloud microphysics over the northeast Pacific during MAGIC. *J. Geophys. Res.*, **120**, doi: 10.1002/2015JD023175.

In prep

Minnis, P., G. Hong, S. Sun-Mack, W. L. Smith, Jr., and S. Miller, 2015: Estimation of nocturnal ice cloud optical depth and water path from MODIS multispectral infrared radiances using a neural network method. *J. Geophys. Res.*

Dong, X., B. Xi, S. Qiu, P. Minnis, S. Sun-Mack, S. Kato, and F. Rose, 2015: A radiation closure study of Arctic cloud microphysical properties using the collocated satellite-surface data and Fu-Liou radaitive transfer model. *J. Geophys. Res.*

Y. B., P. Yang, P. Minnis, N. Loeb, and S. Kato, 2015: Ice cloud optical property parameterization based on a two-habit model for applications to global circulation models. *J. Climate*.

CERES, 2015: Edition 4 SSF Data Quality Summary.

CERES MODIS Status (Coll 5 Data)

- Ed2 processing
  - *Aqua: through May 2015, will continue until ED4 ADMs completed*
  - *Terra: through May 2015, will continue until Ed4 ADMs completed*

- Ed4 Beta-2 processing
  - *Aqua: through December 2012*
  - *Terra: through February 2013*

CERES VIIRS Status

- Ed1 delivered, processing begun
  - *Jan – Feb 2012; July 2013 run offline*

CERES GEOSat Status

- Ed4-beta: uses 3/4 channel cloud retrievals with appropriate satellites
  - *beta because cleaned data are not yet available*
  - *cleaning continues*

CERES Data Quality Summaries

- DQS clouds validation for Ed4 complete (40 pp.)
  - Full DQS not available yet, but copy of clouds validation available
- DQS Validation started for VIIRS Ed1
- DQS validation for GEOSat analyses next

MODIS Edition-4 beta 2 Cautions

- Error in model look-up tables discovered
  - *mismatch between 0.65 and 3.8-μm optical depths*
  - *affects particle size and phase selection primarily*
  - *impacts ADM selection => fluxes*
- Thick ice cloud-top height correction not applied
  - *affects cloud base and is inconsistent with VIIRS Ed1*
  - *can be applied externally post facto, simple equation*
- *CO2 thin ice cloud height correction to Zeff may OE radiative height*
  - *yields more accurate Ztop but underestimate OLR wrt CERES*
  - *Convinced SARB to use Zeff as before => better agreement w/ CERES*
  - *CO2 not used in GEOSat now, 2-channel SIST or VISST only used*
- Error in parameterization of 1.24 and 2.13 μm reflectances
  - *minor effect on Re retrievals and tau over ice/snow*
- *Errors in 1.24 and 2.13 μm reflectance models*
  - *significant effect on Re retrievals & tau over ice/snow*
  - *differences with VIIRS shown*
- *Bug in skin temp code, MODIS Ed4 ~~& VIIRS Ed1~~*
  - *affects some desert temperatures, default to MOA*

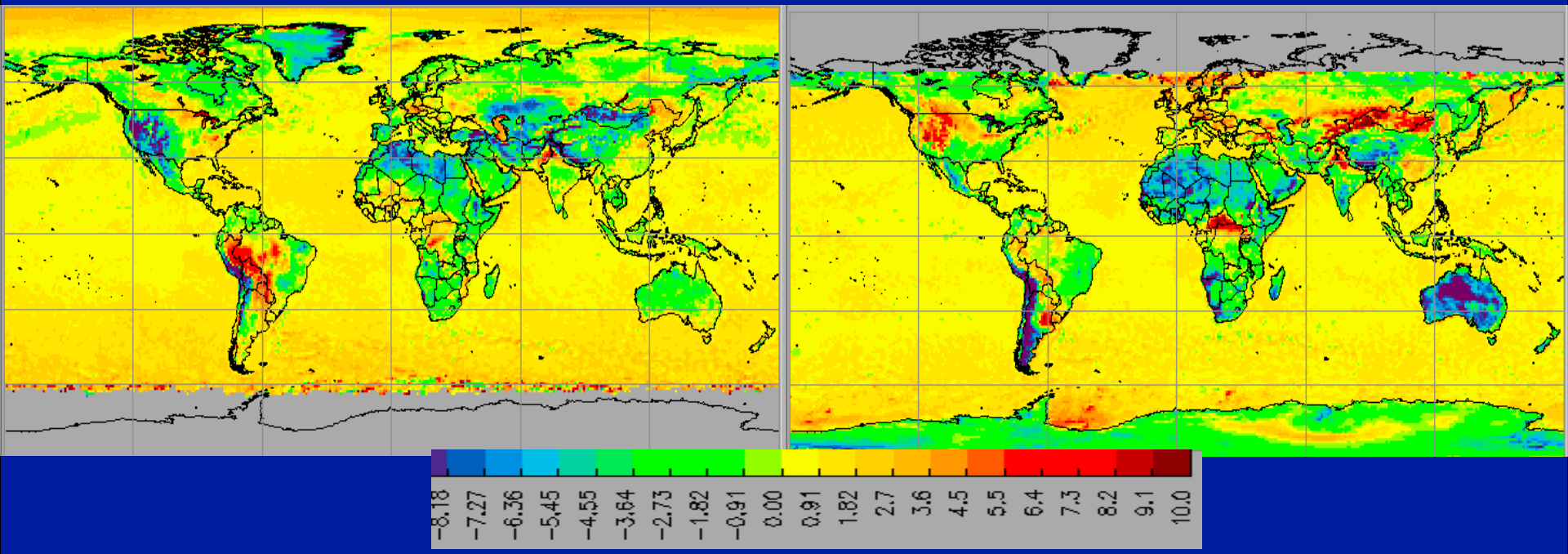
Clear-sky Skin Temperature Bug

- MODIS Ed4 code had bug that limited the computation of Tskin from clear-sky 11-μm brightness temperatures
  - too late to fix before processing began

- Same code bug was in VIIRS Ed1, but processing had been delayed, so the bug was removed and more reliable Tskin values are expected

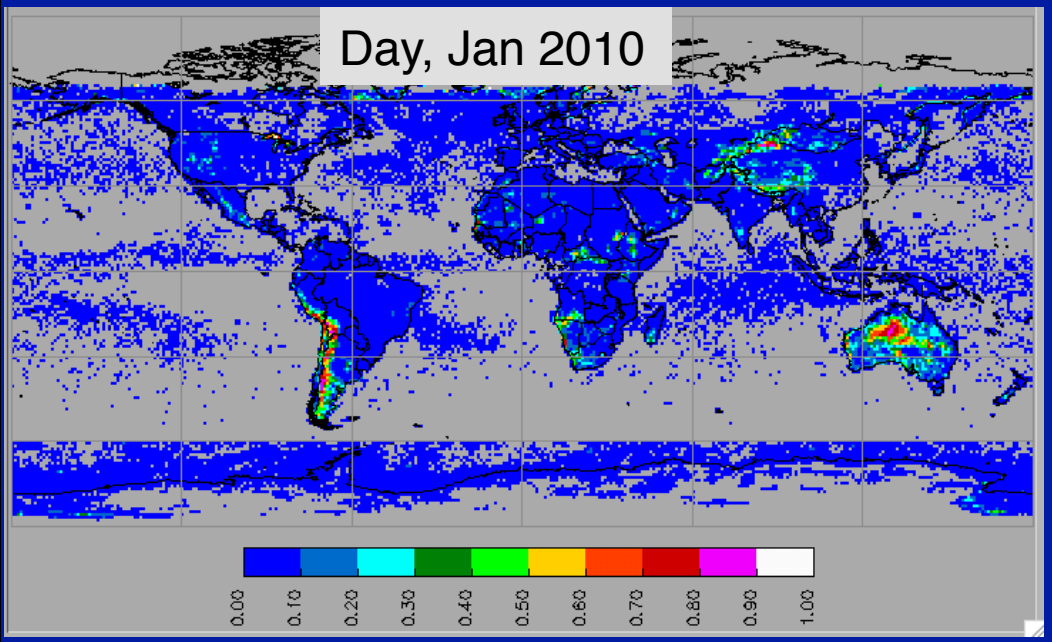
Aqua Mean MOA Clear-sky Temperature – Observed, Day

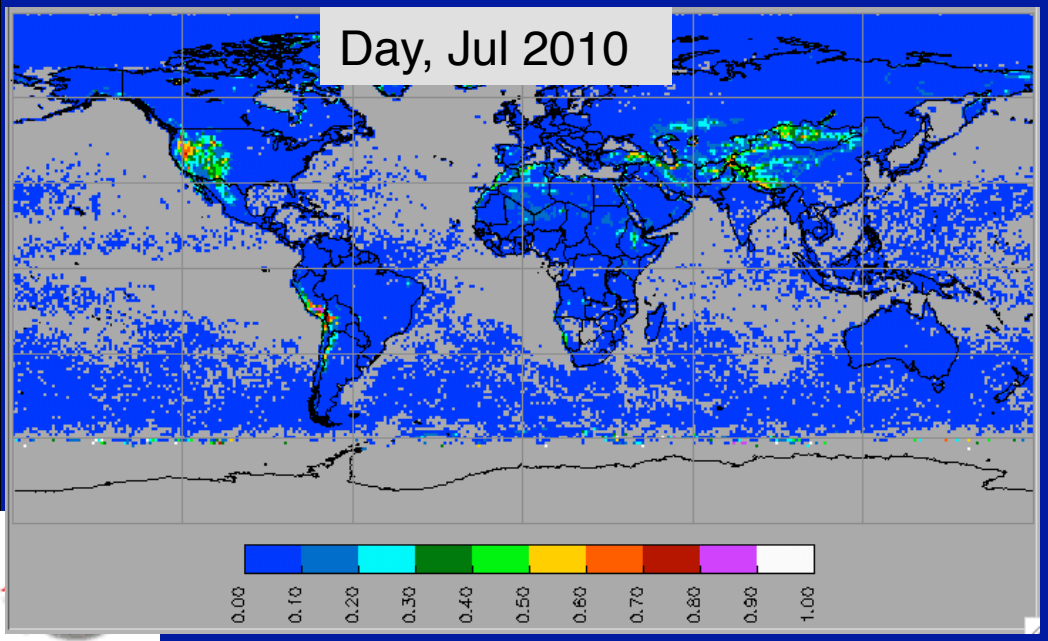
- Temporary statement left in Ed4 & Ed1 code to prevent core dumps
  - If |Tclr(MOA) – Tclr(OBS)| > 10, then Tskin = Tskin(MOA)



- In arid mountainous regions, Tclr(MOA) averages often colder than observed
  - indicates no actual Tskin computed for many samples in this area

Frequency of Replacing Aqua Tskin with MOA

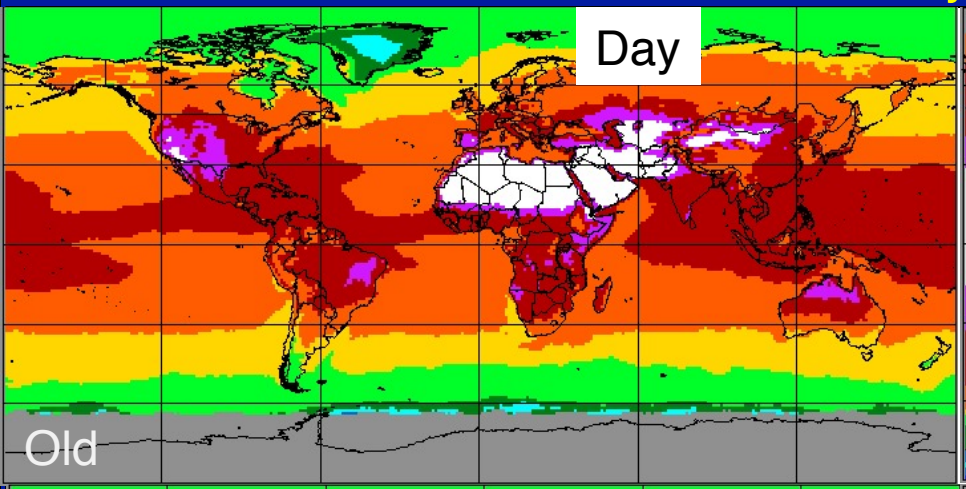


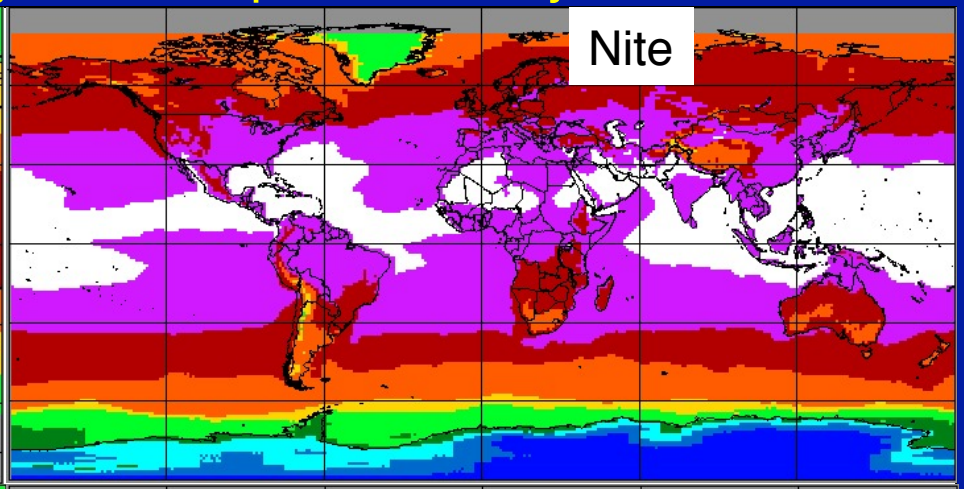


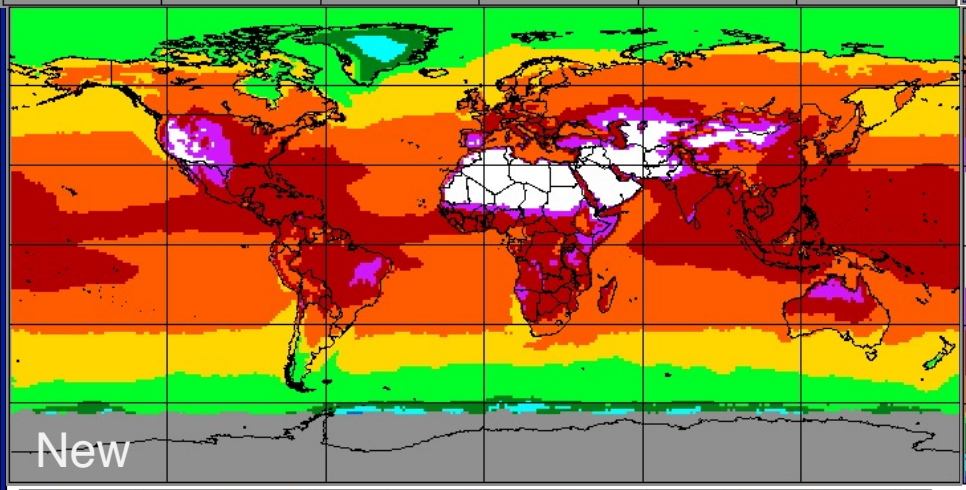
- Tskin not retrieved over hot desert areas in up to 80% of cases over SH
- Smaller substitution rate over NH
- Affects computation of OLR downstream

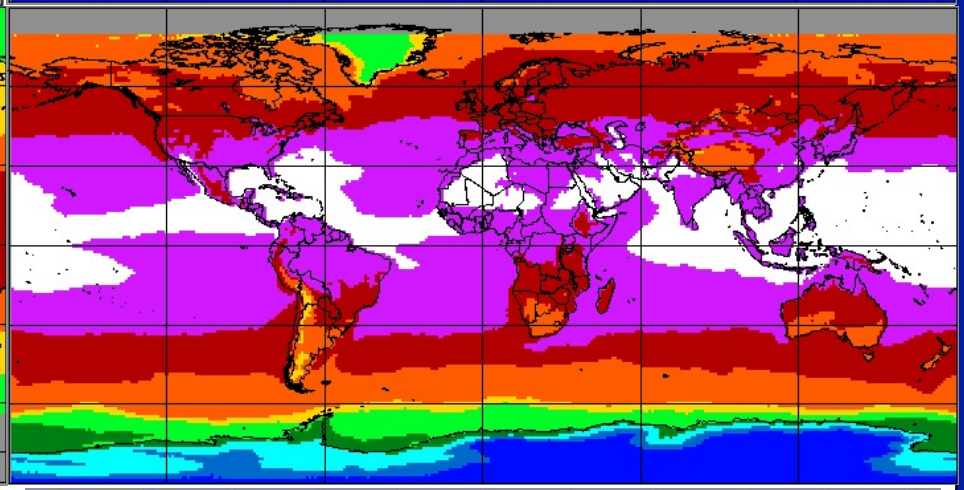
- Should be easy to replace these "bad" Tskin values with some post-processing of the Ed4 SSF
- Add Tskin to QC for next Eds

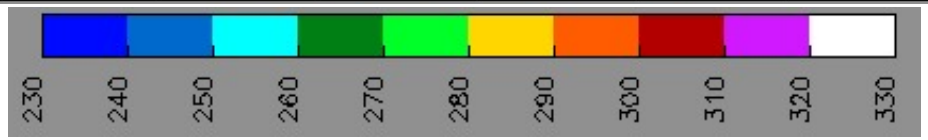
SNPP VIIRS Mean Clear-Sky Skin Temperature, July 2013





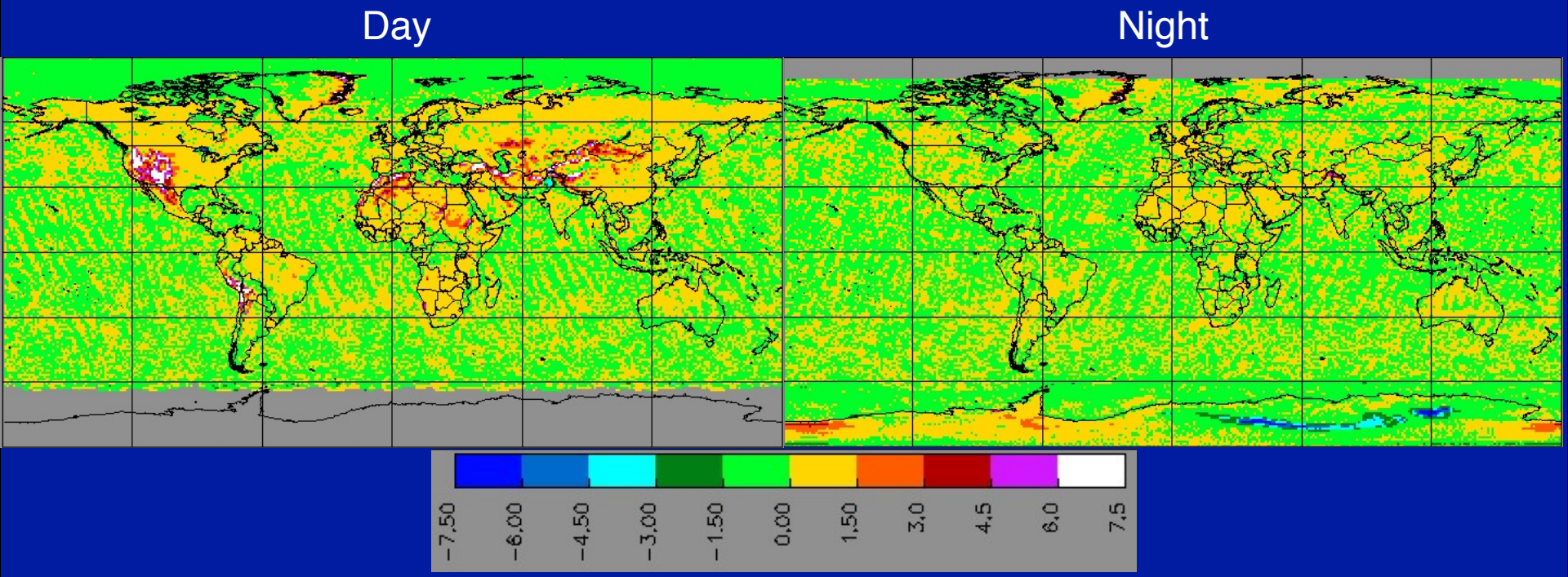






- Old: Few temperatures exceeding 325 K allowed to pass through the filter
- New: Daytime changes primarily over NH deserts
- New: nighttime changes few & far between (note scale change)

VIIRS Mean Clear-sky Temperature Difference, After – Before July 2013

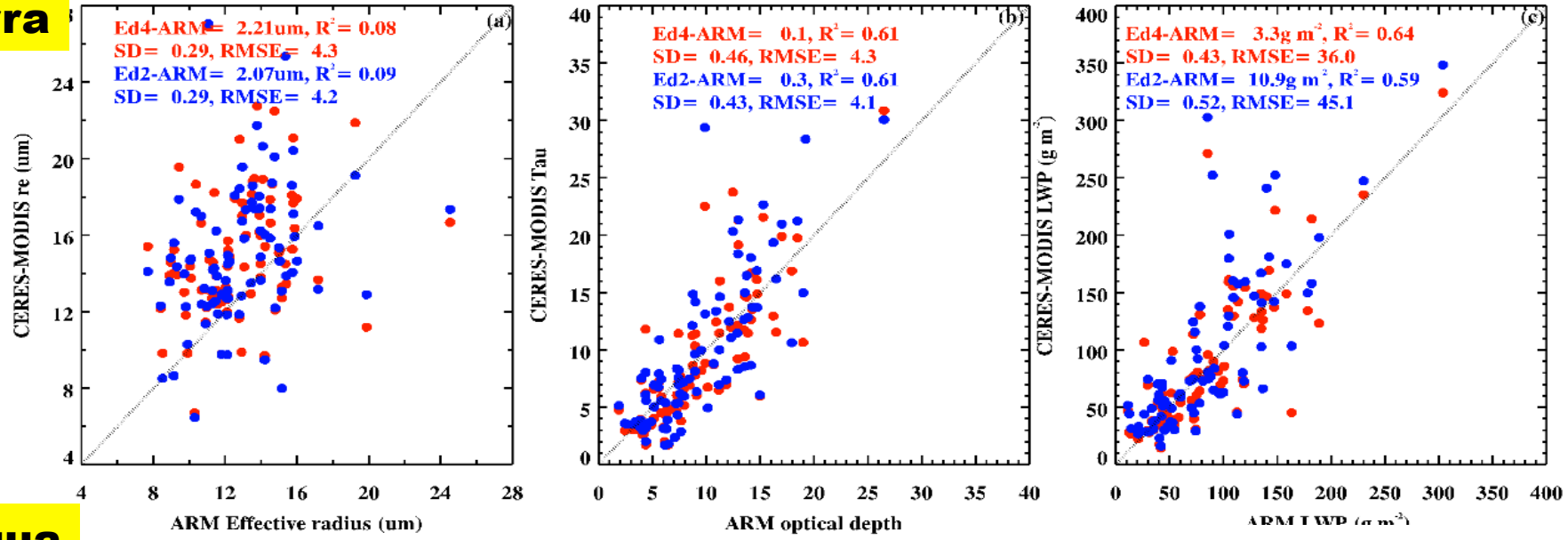


- In most land regions, Tclr(MOA) averages now higher than with bug
  - Tskin should be much more reliable over land for VIIRS Ed1

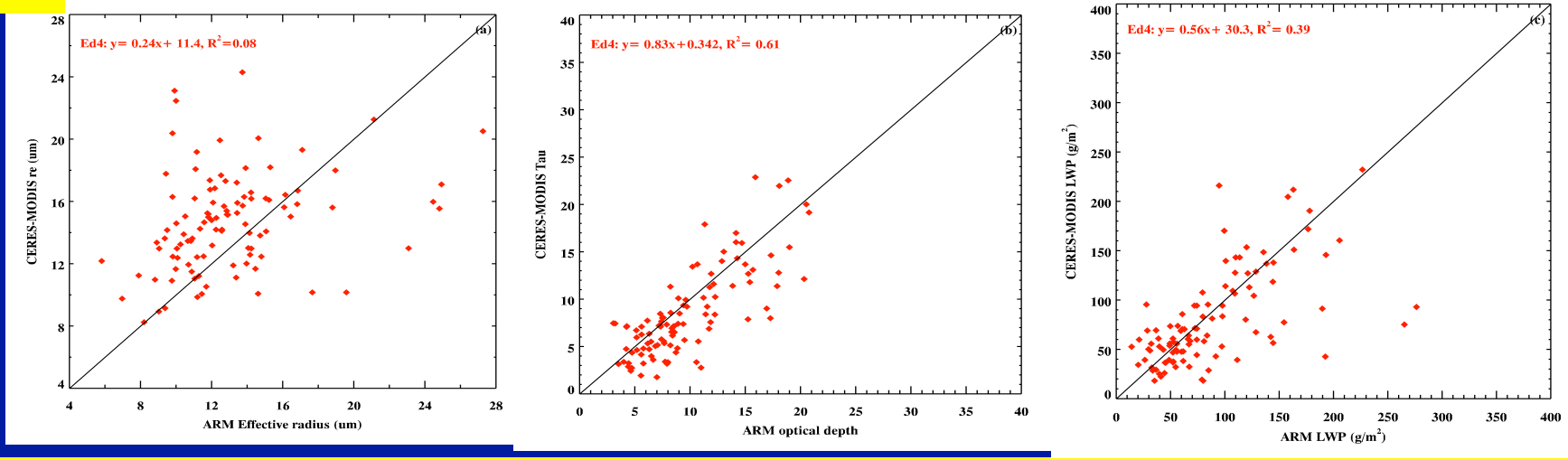
North Slope of Alaska ARM Comparisons for for Snow-Free Conditions

Terra and Aqua Cloud Properties against ARM retrievals

Terra



Aqua



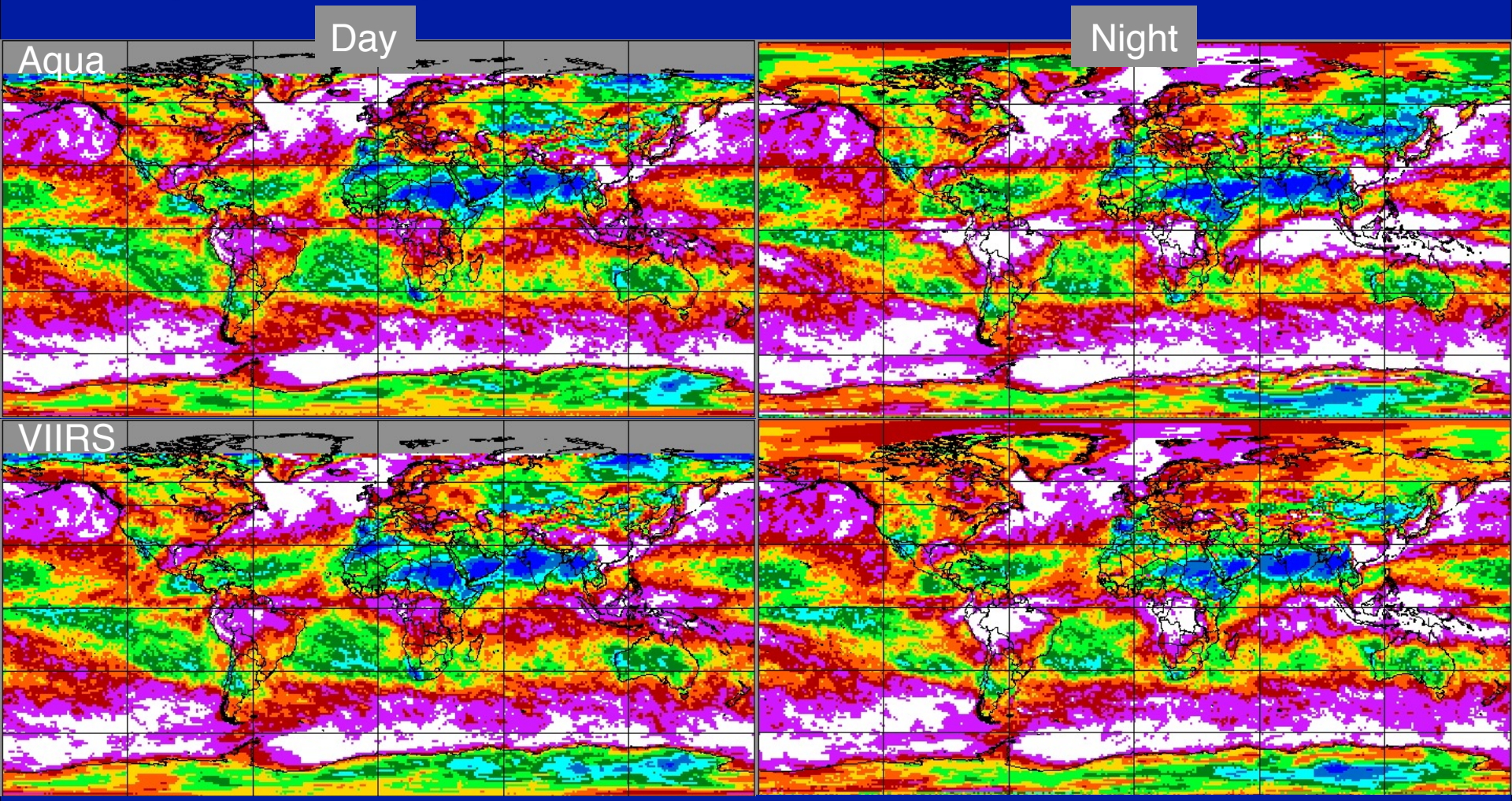
1) **Terra:** ARM re=12.8 vs. Ed4=15.1 um, ARM tau=9.5 vs. 9.6, ARM LWP=84.1 vs. 87.4 gm^{-2}
2) **Aqua:** ARM re=13.0 vs. Ed4=14.6 um, ARM tau=9.8 vs. 8.5, ARM LWP=88.1 vs. 80.1 gm^{-2}

Summary

		Re	Tau	LWP	SFC SW↓ cloud	T_{trans}	TOA SW↑	R_{TOA}
TERRA	OBS				184.7	0.48	206.3	0.44
	ARM	12.8	9.5	84.1	170.5	0.47	215.9	0.46
	ED2	14.9	9.8	95.0	174.3	0.49	212.5	0.45
	ED4	15.1	9.6	87.4	176.9	0.49	210.8	0.45
AQUA	OBS				202.1	0.46	239.8	0.41
	ARM	13.0	9.8	88.1	196.6	0.49	252.9	0.45
	ED4	14.6	8.5	80.1	210.0	0.53	242.9	0.43

MEANS
&
VARIATIONS

Aqua & First Operational VIIRS Mean Cloud Fractions, Feb 2012

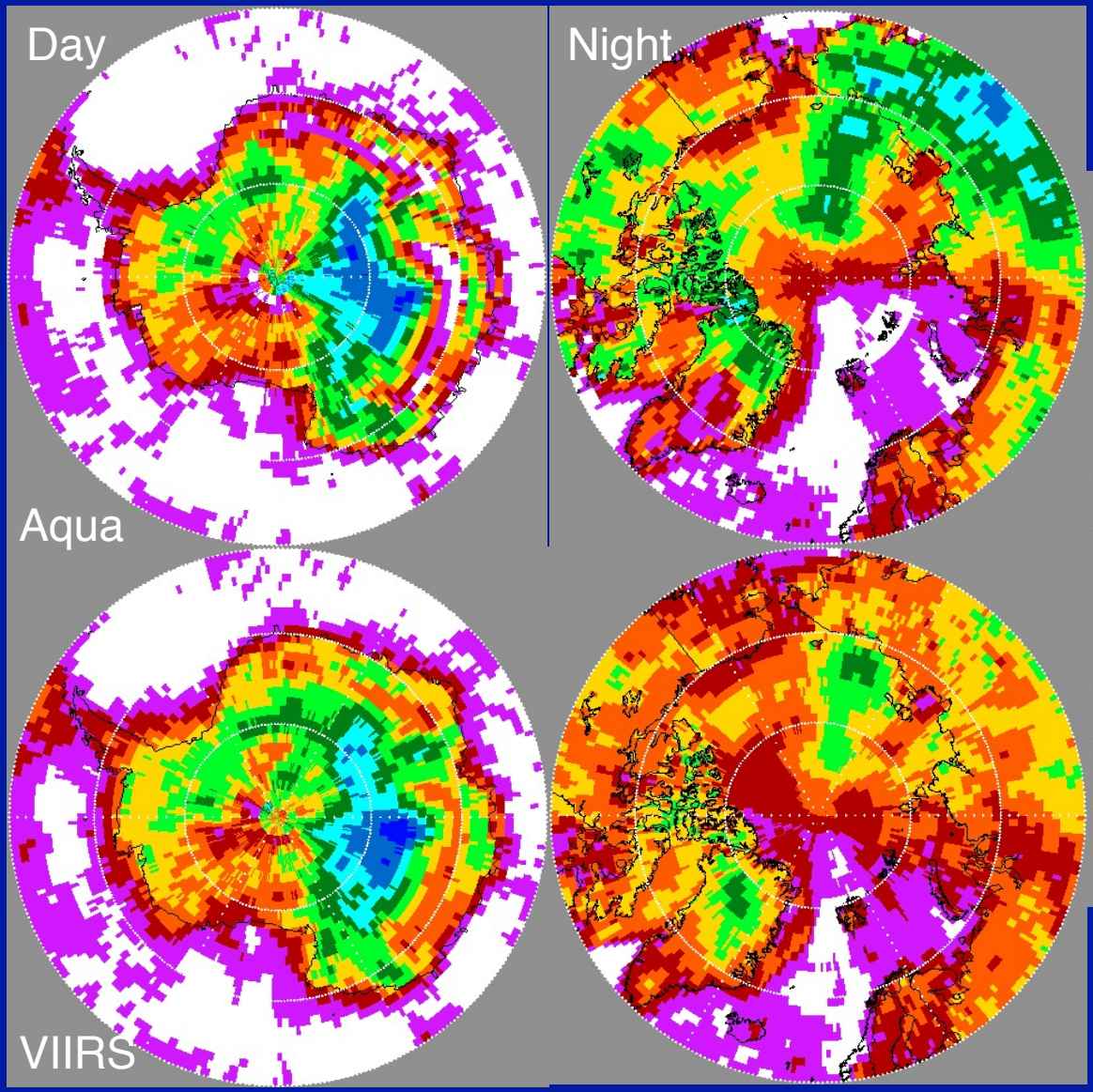


	Aqua	SNPP
Global	0.652	0.682
NP	0.647	0.644
Polar	0.682	0.678

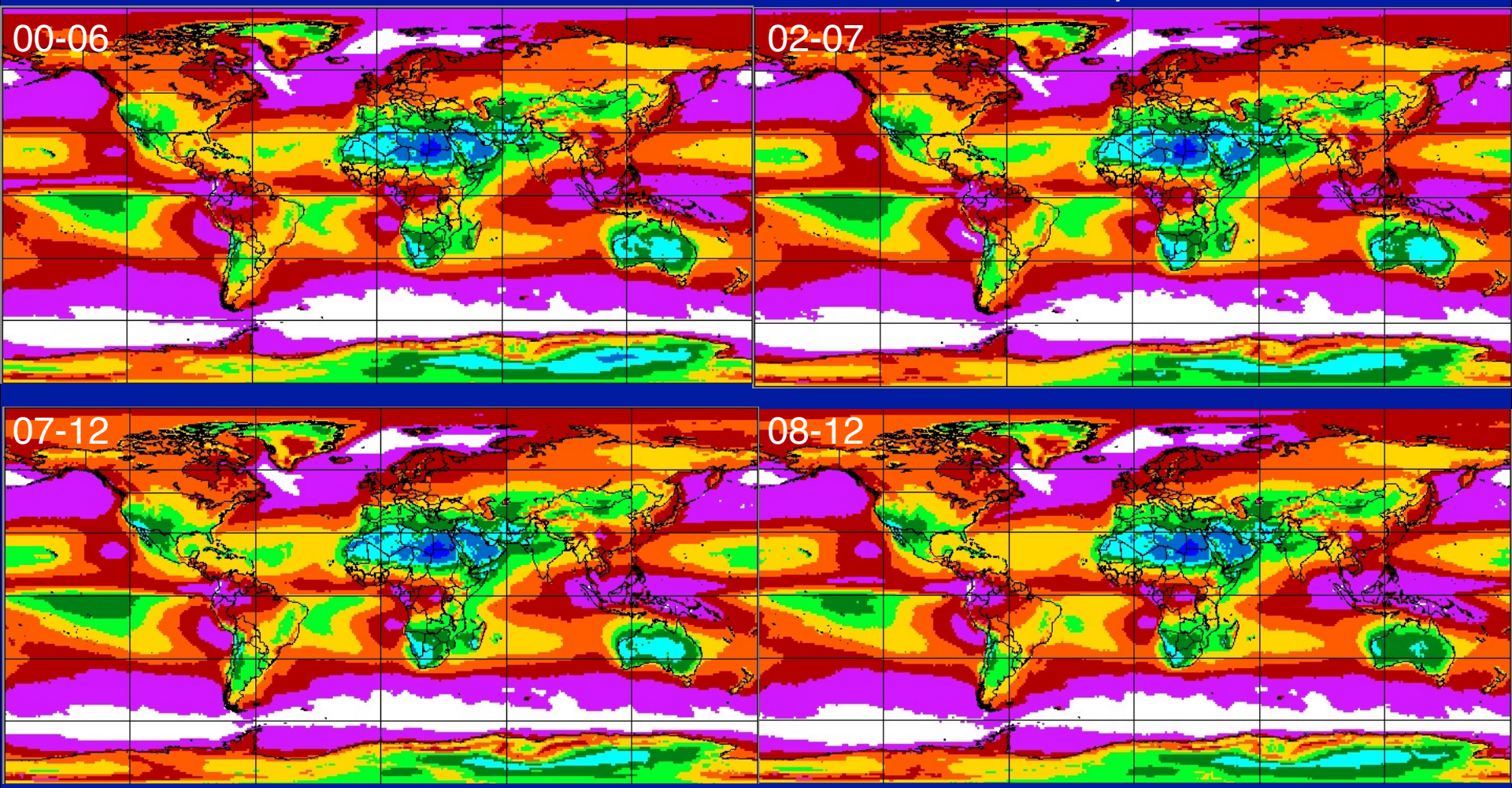
- VIIRS & MODIS very similar in daytime
- Largest differences over TWP & Arctic at night

Aqua & First Operational VIIRS Mean Cloud Fractions, Feb 2012

- VIIRS has a bit less than MODIS in Antarctic night
- VIIRS has much more cloud cover over Arctic at night
- Overall, it is balanced out Yielding 0.004 difference



Terra and Aqua Mean Cloud Fractions, 2000-2012

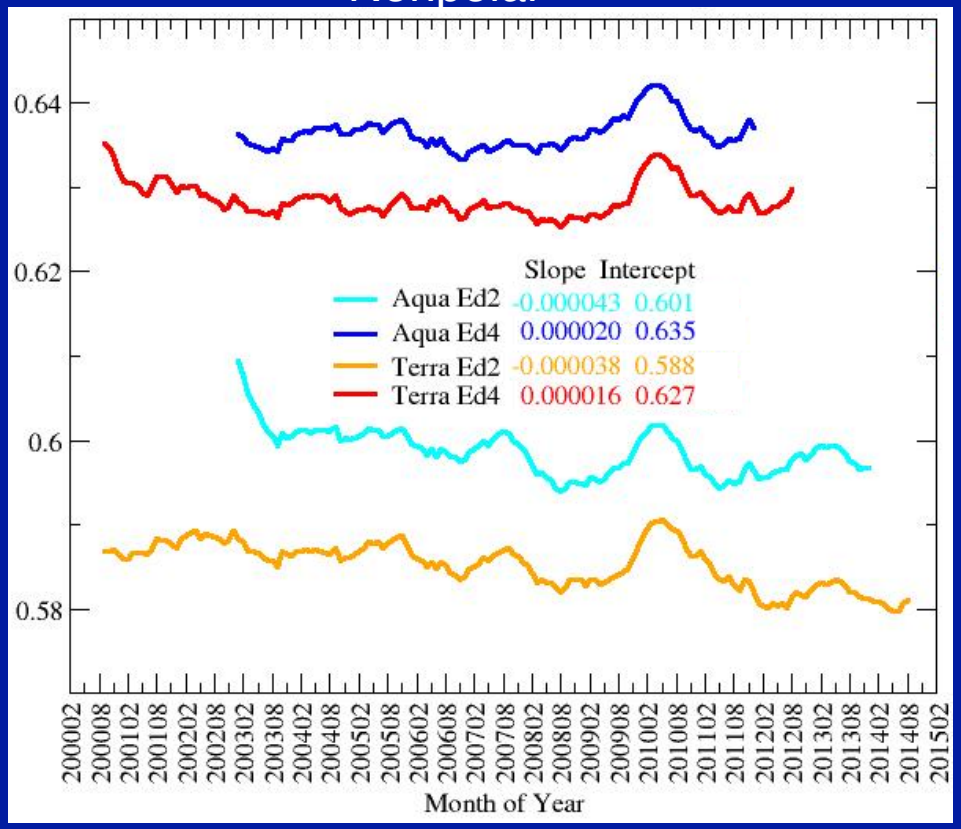


- Terra and Aqua very similar, trends may shed more light
- Apparent drop in Arctic cloud cover, slight increase in Antarctic clouds
- Slight shifts in coverage over many areas

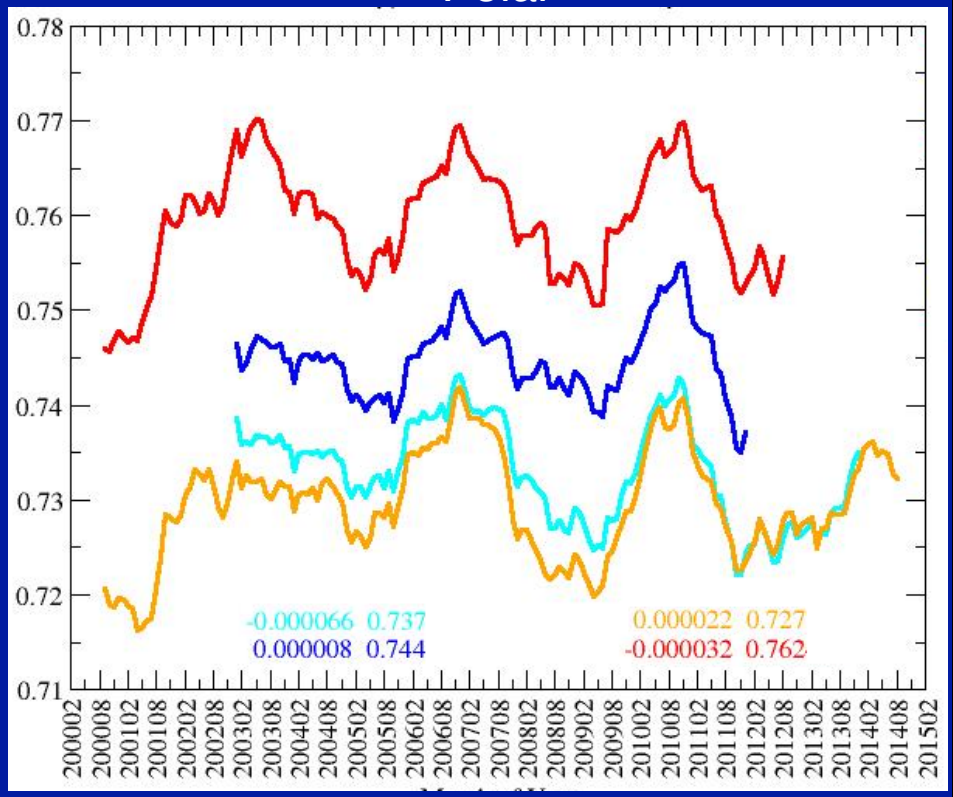
Terra and Aqua Day Cloud Fractions, 2000-2012

12-month running means

Nonpolar



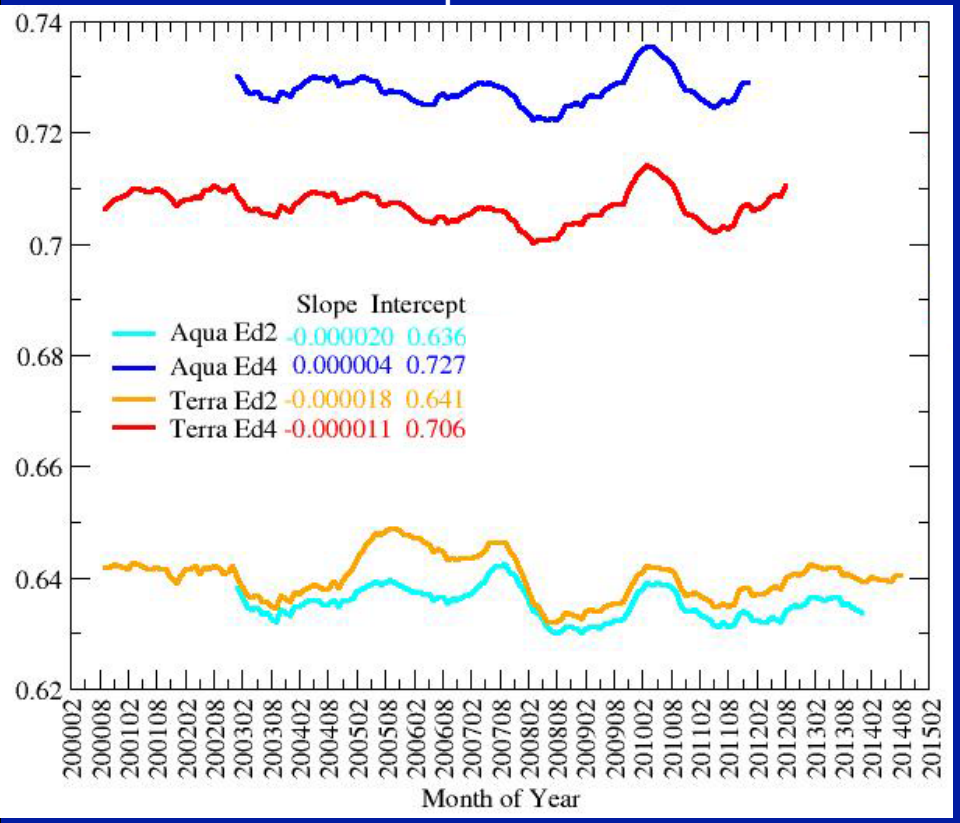
Polar



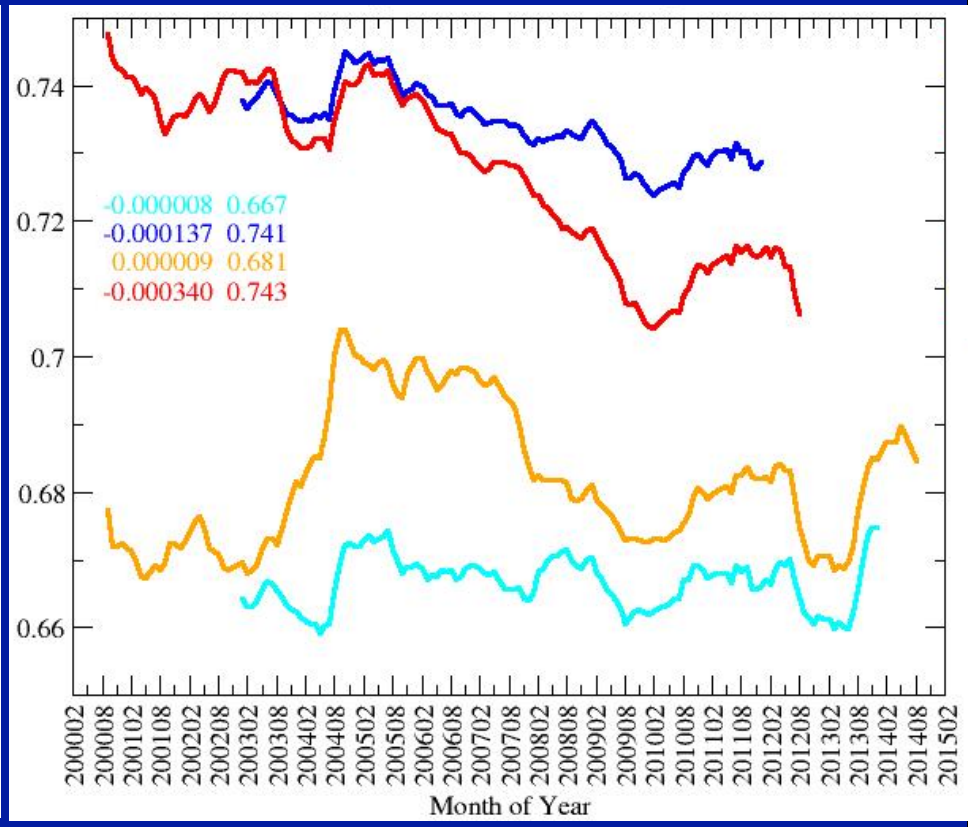
- Terra & Aqua track well in both zones, 2010 jump
- 4-y cycle in polar regions?
- insignificant 0.002/dec trend in NP regions, -0.002 in Polar regions
- insignificant day global trend: 0.002/dec

Terra and Aqua Night Cloud Fractions, 2000-2012

Nonpolar



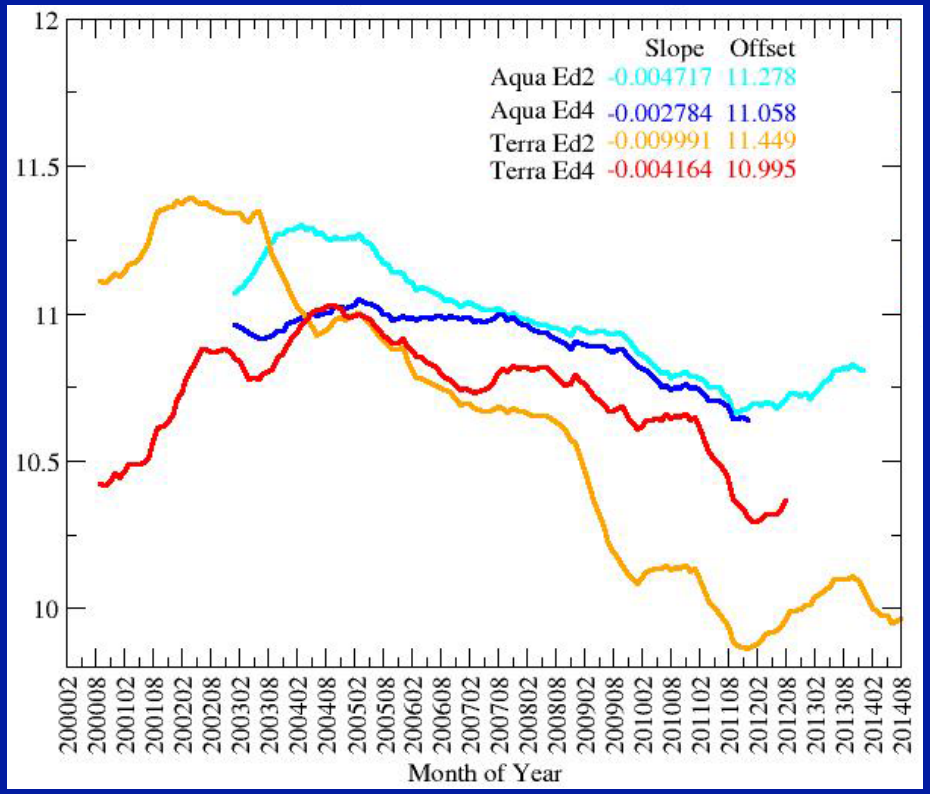
Polar



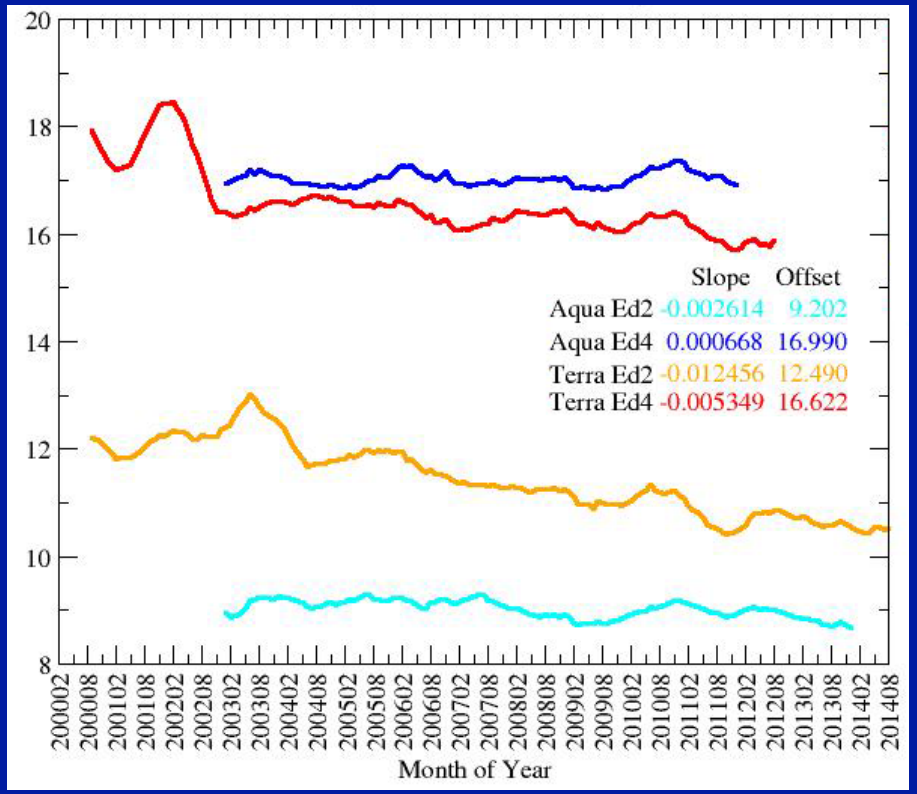
- large increase in clouds at night, 0.08
- Terra & Aqua track well in NP regions, 2010 jump
- no 4-y cycle in polar regions, Terra has significant drop after 2006
  - *3.7, 11, or 12-μm calibrations?*
- no trend in NP regions, -0.029/dec in Polar regions?
- global night trend: -0.006/dec global night+day trend: -0.002/dec

Terra and Aqua Mean Cloud Optical Depths, 2000-2012

Nonpolar



Polar

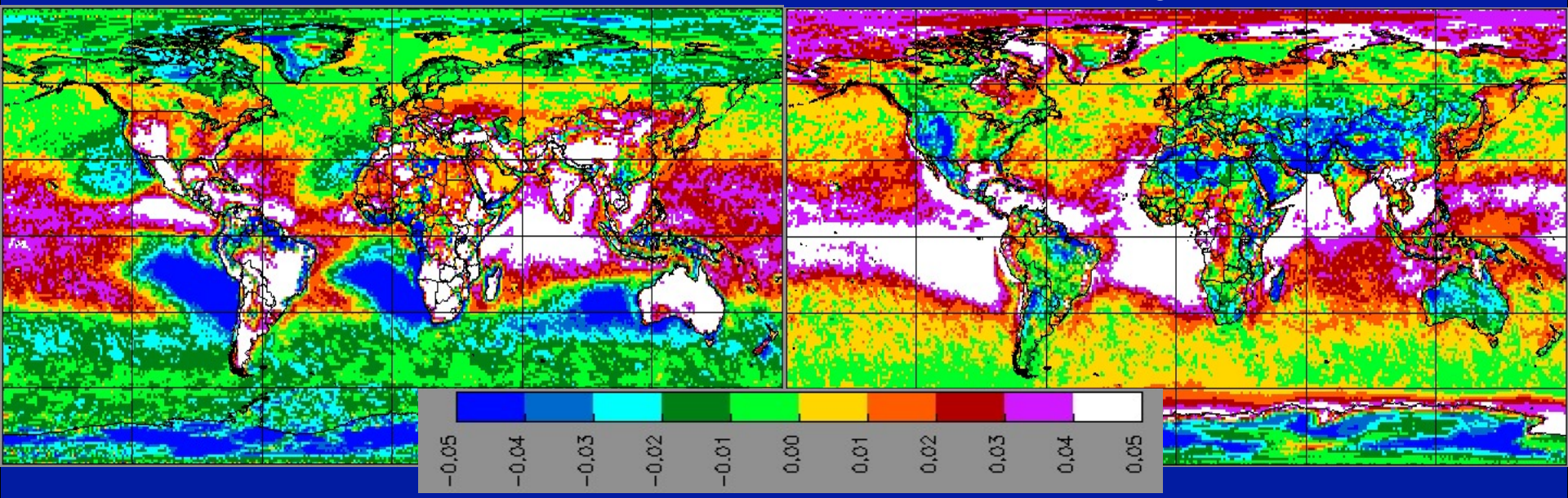


- Terra increase in 2000-2001 due to calibration jump in 2002
- Polar trend in Terra like a calibration artifact
- Terra & Aqua trends over Nonpolar areas, -5 & 3%/dec
  - likely driven by unaccounted gain degradations
    Aqua VIS gain has negative trend after 2007
    Terra also, but smaller (Terra tied to Aqua) *(Doelling et al. 2015)*

Aqua – Terra Mean Cloud Fractions, 2002-2012
3-h Difference, 1:30 – 10:30 LT

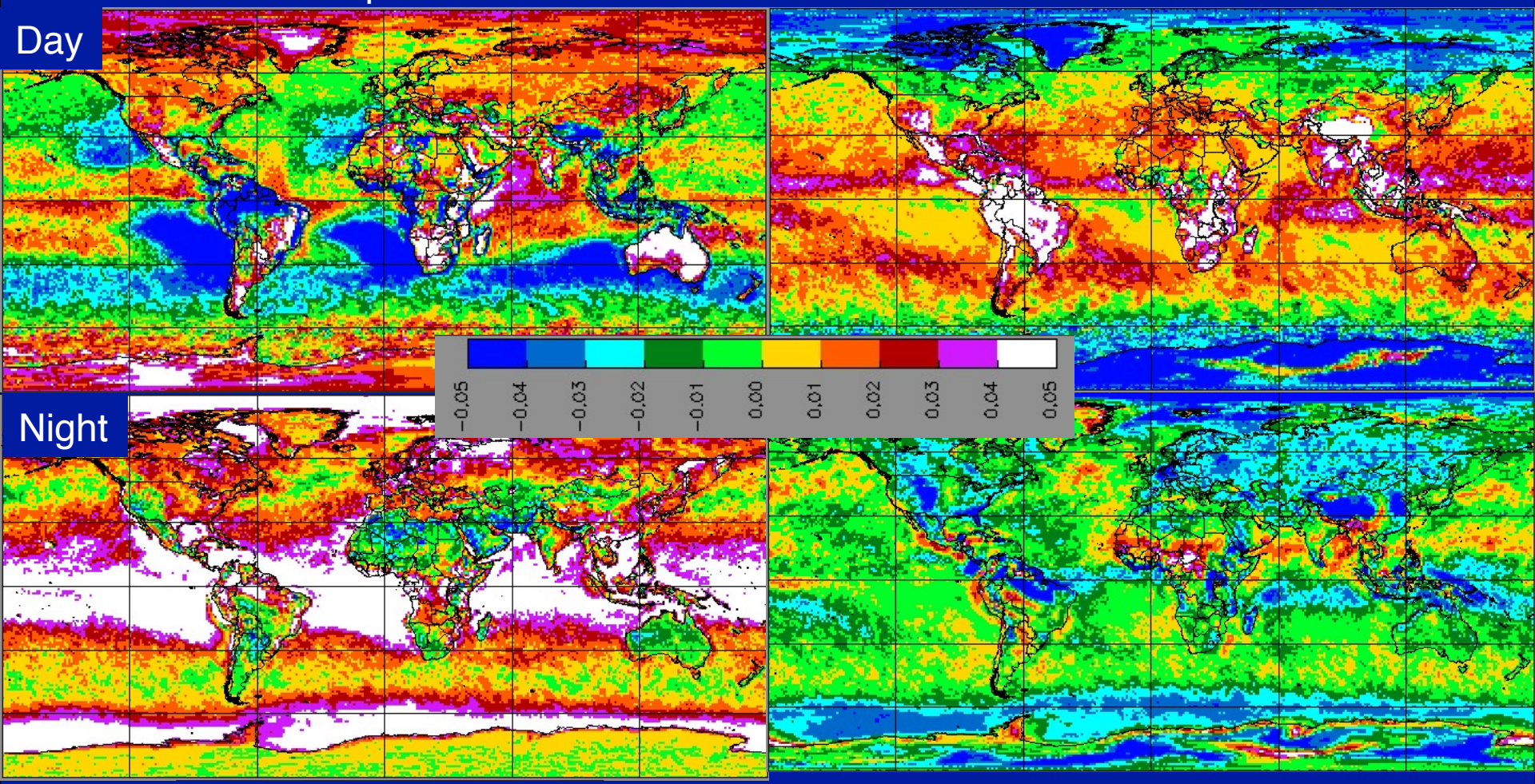
Day

Night



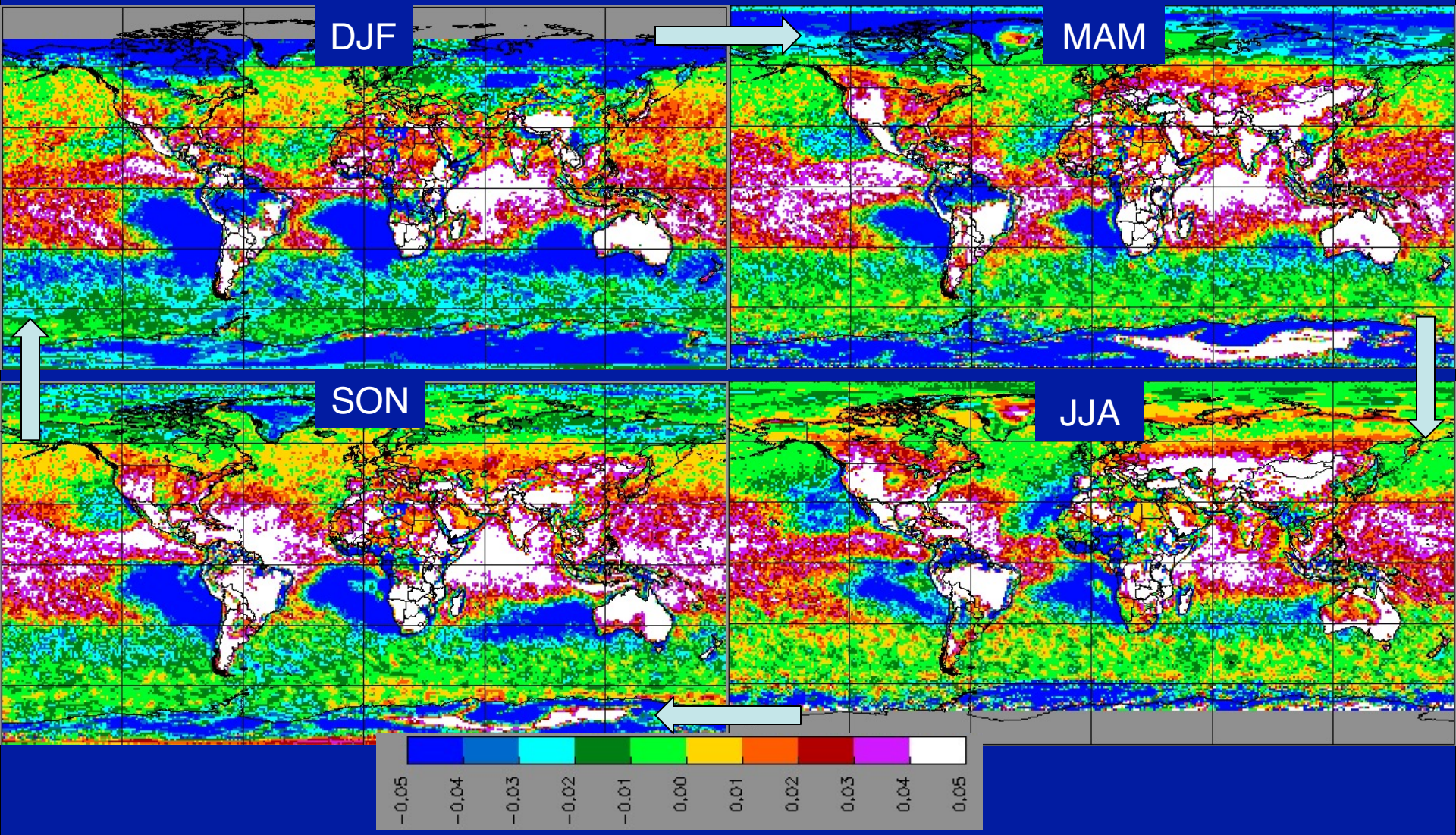
- Greatest negative changes
  - *SH marine stratus (day)*
  - *mountains & deserts, northern So. America*
- Greatest positive changes
  - *day: mountainous land, deserts, eastern tropical Pacific & Indian Ocean*
  - *night: tropical oceans*
- Large swings in polar regions not a diurnal effect, due to sampling
- Indian Ocean changes need further investigation

Aqua – Terra Mean Cloud Fractions, 2002-2012
3-h Difference, 1:30 – 10:30 LT



- Building (or exposing) of tropical low clouds occurs in depth of night
- Trade Cu appear to build around noon and midnight
- Ice clouds collapse over mtns at night, build along tropical coasts
  - build over marine convergence areas

Seasonal Aqua – Terra Mean Cloud Fractions, 2002-2012
Daytime 3-h Difference, 13:30 – 10:30 LT

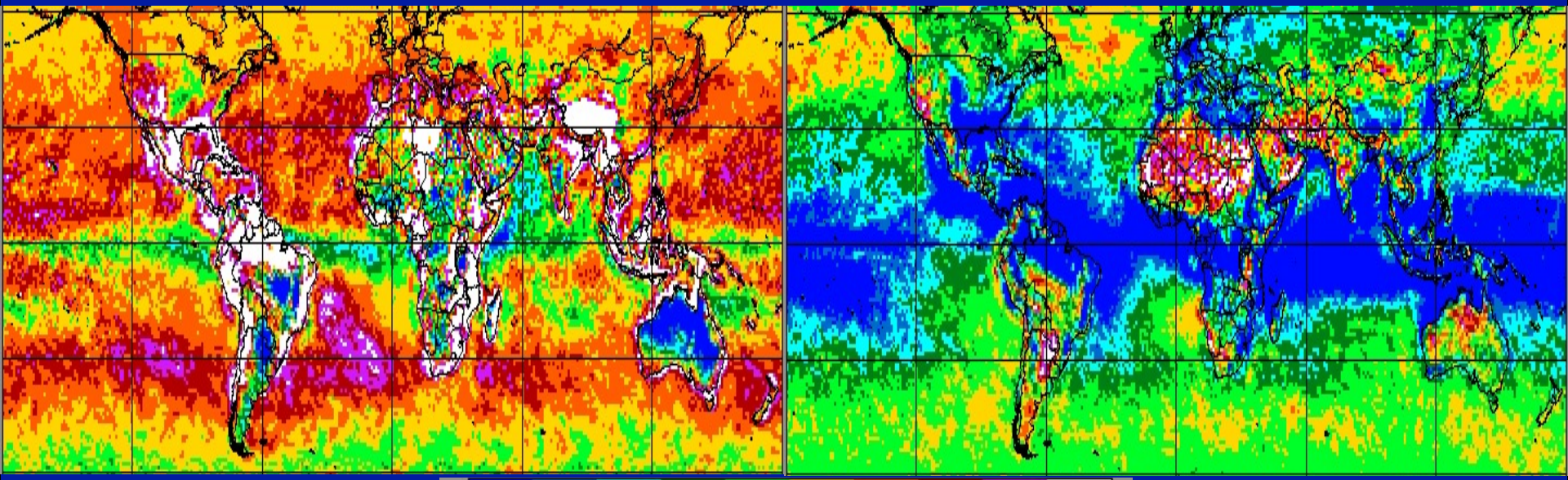


- Marine stratus: SH *always greatest differences, max in DJF; NH max in JJA*
- Convective peaks over land follow max solar, except mountain-valley

Aqua – Terra Mean Cloud Heights, 2002-2012
3-h Difference, 1:30 – 10:30 LT

Day

Night



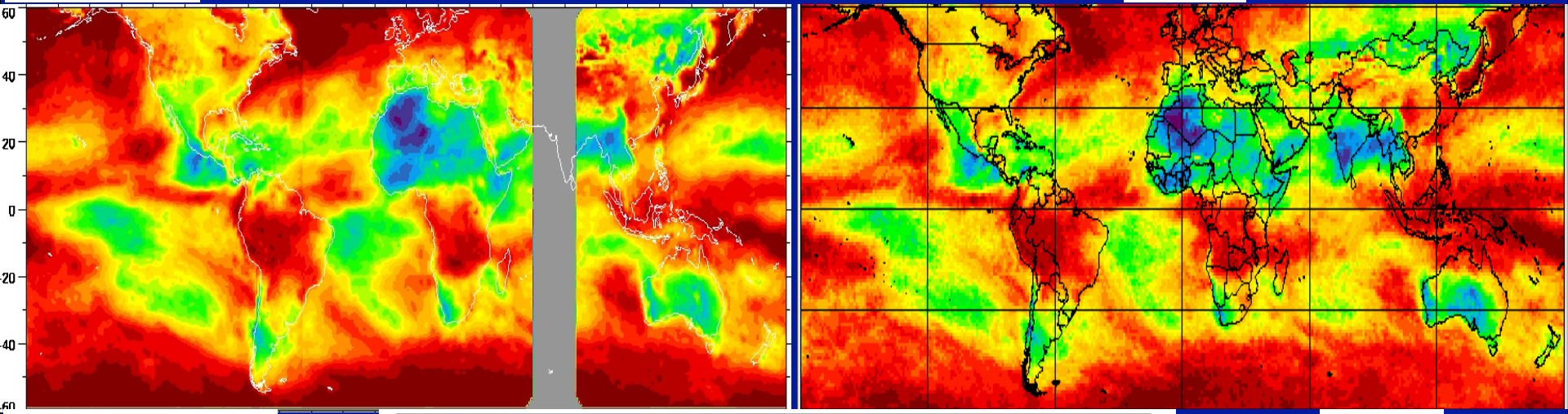
- Small increases in marine strat heights into afternoon, small decreases at night
- Greatest increases during day over mountains and coastal areas
  - *surrounding great rift of Africa, tropical coasts of NA, SA, & Africa*
- Day decreases over relatively low lying inlands
- Night decreases over most of tropics, increases over low-lying interiors
  - *Terra IR calibration effects?*

CERES GEOSat Cloud Properties

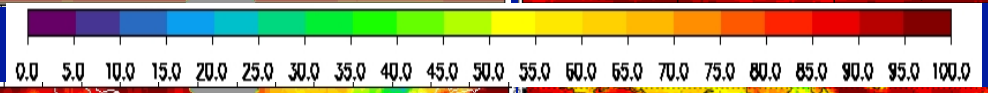
Mean Cloud Fraction, GEO vs MODIS, January 2008

GEO day

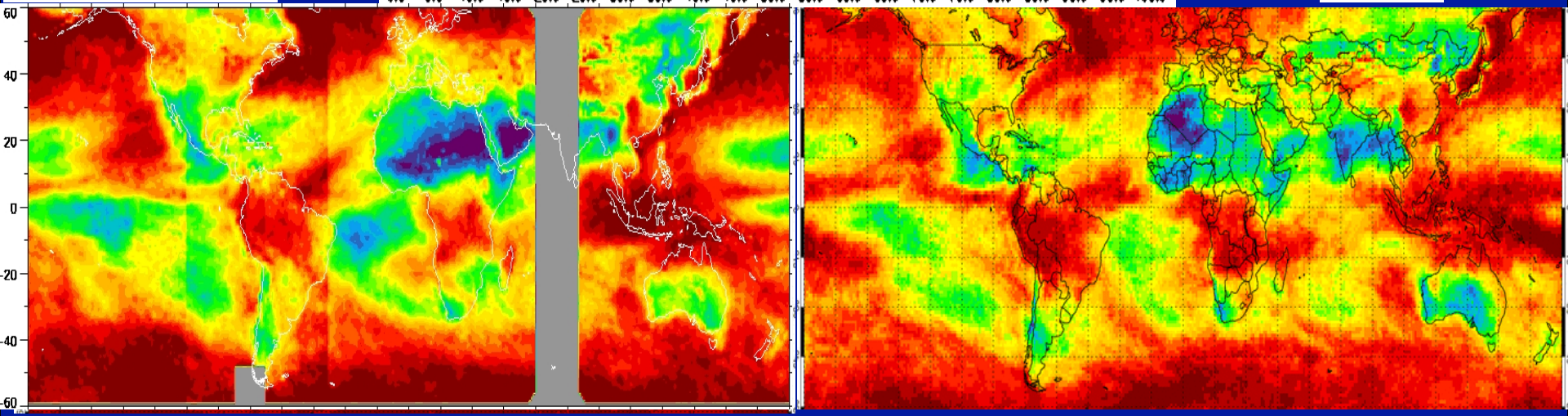
Terra



GEO @1330

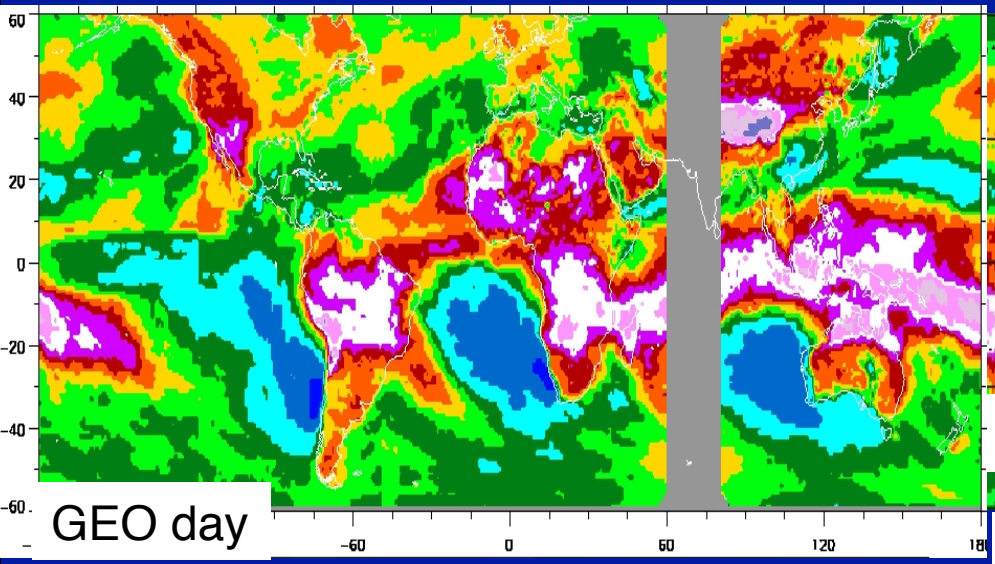


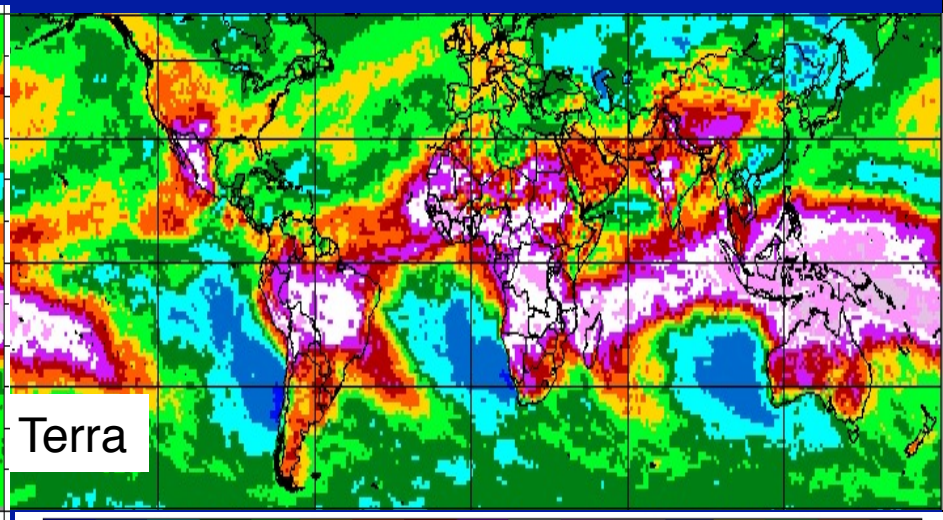
Aqua

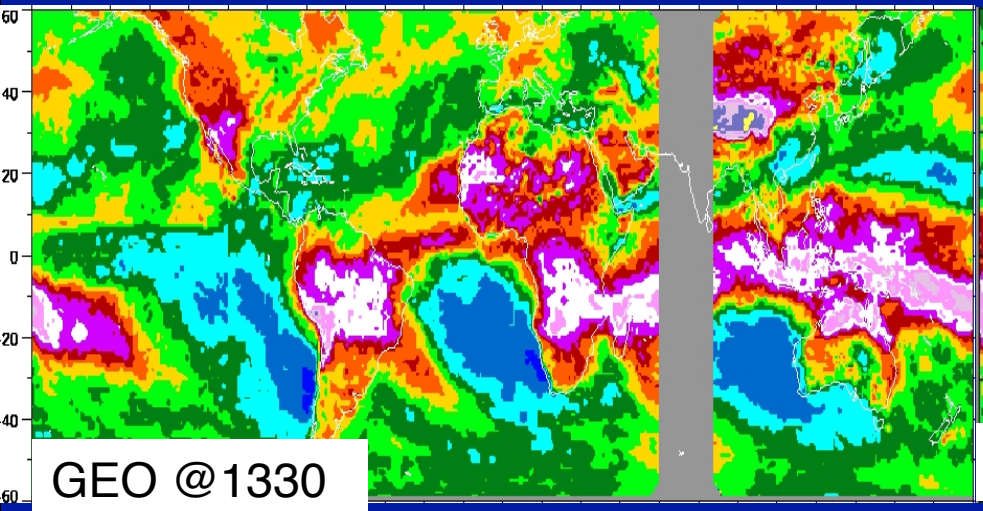


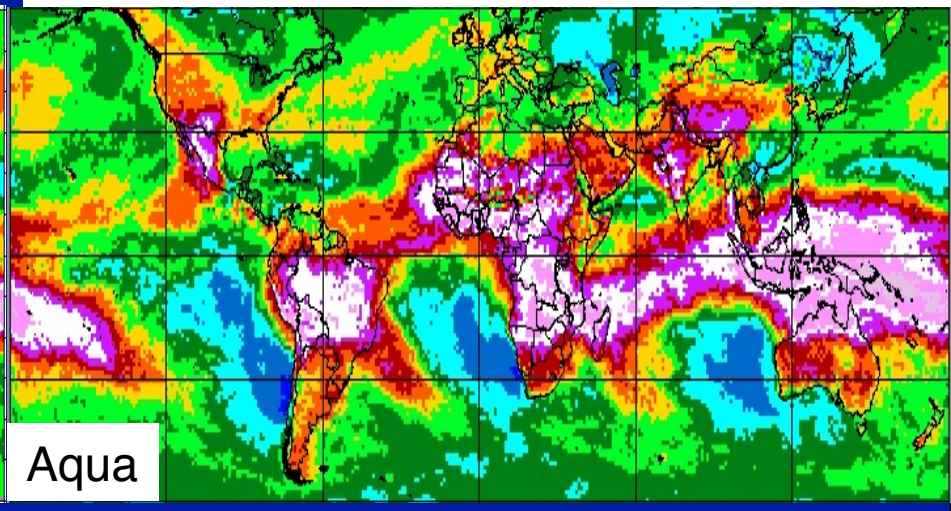
- Mean cloud distributions very consistent, discontinuities in hourly means
  - *GEO > others in corners and high latitudes because of hi SZAs*

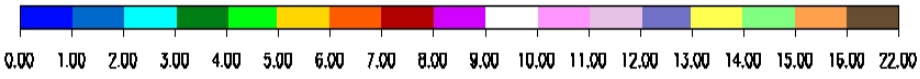
Mean Cloud Effective Heights, GEO vs MODIS, January 2008, day





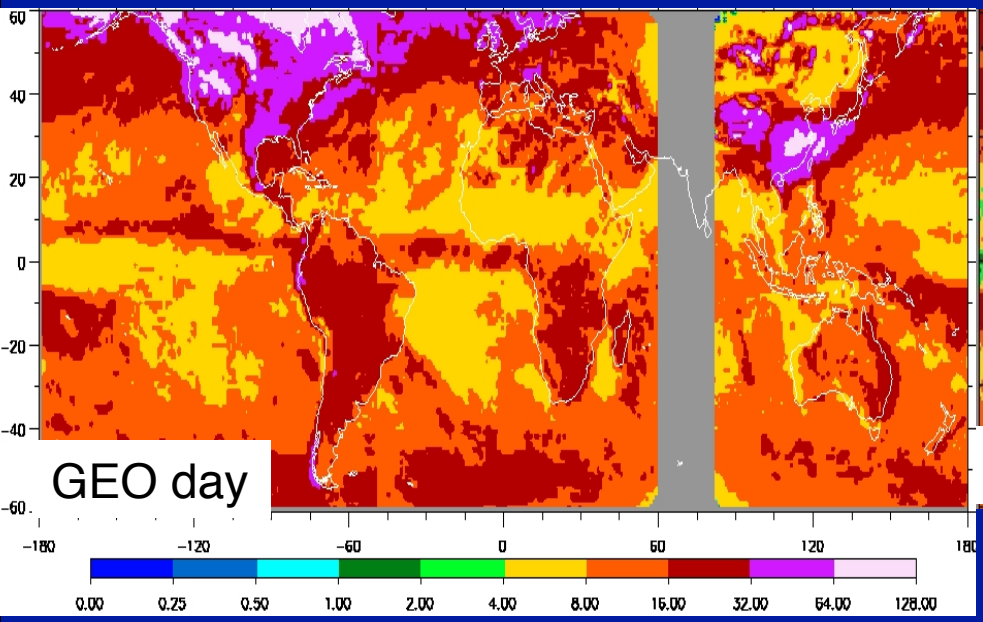


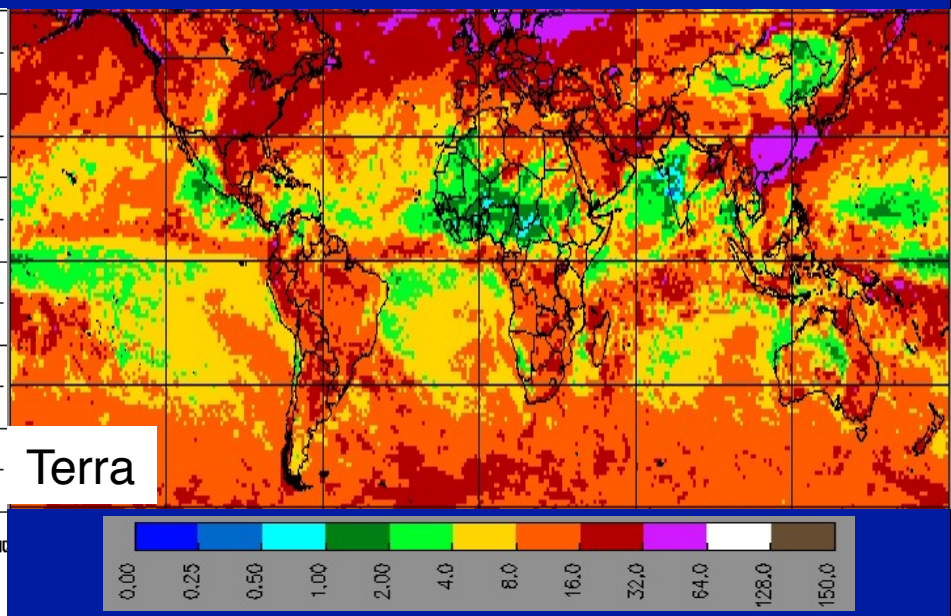


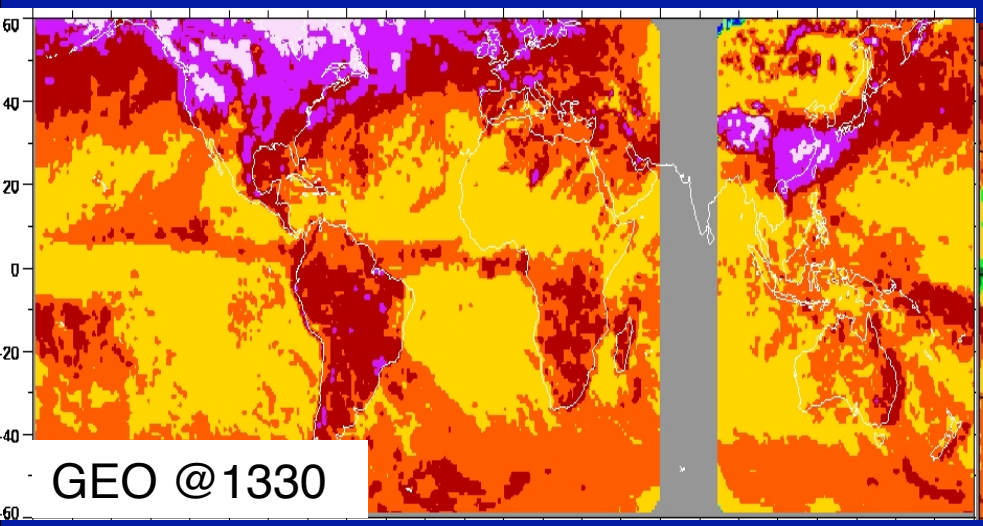


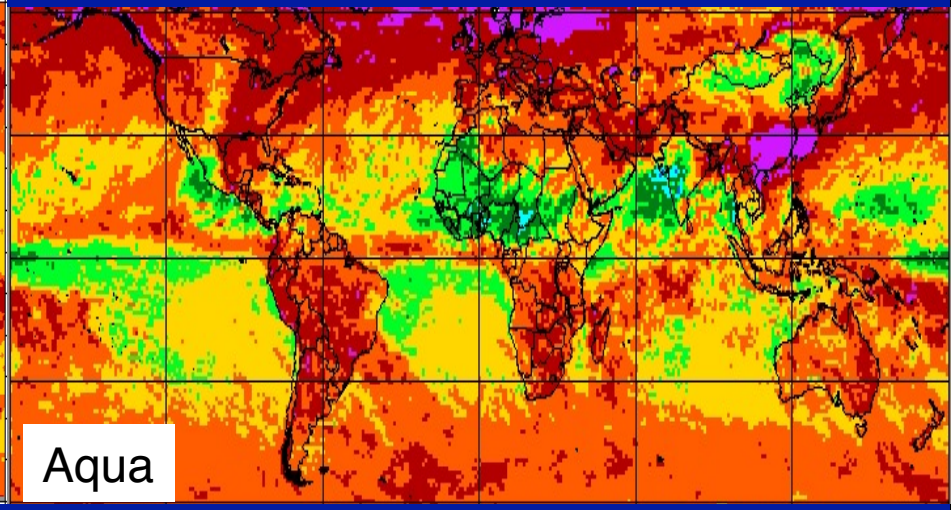
- GEO marine low heights very similar to MODIS
- Low heights most different in snowy areas and corners
- Ice cloud heights slightly lower: *resolution? channel complement?*

Mean Cloud Optical Depth, GEO vs MODIS, January 2008, Day







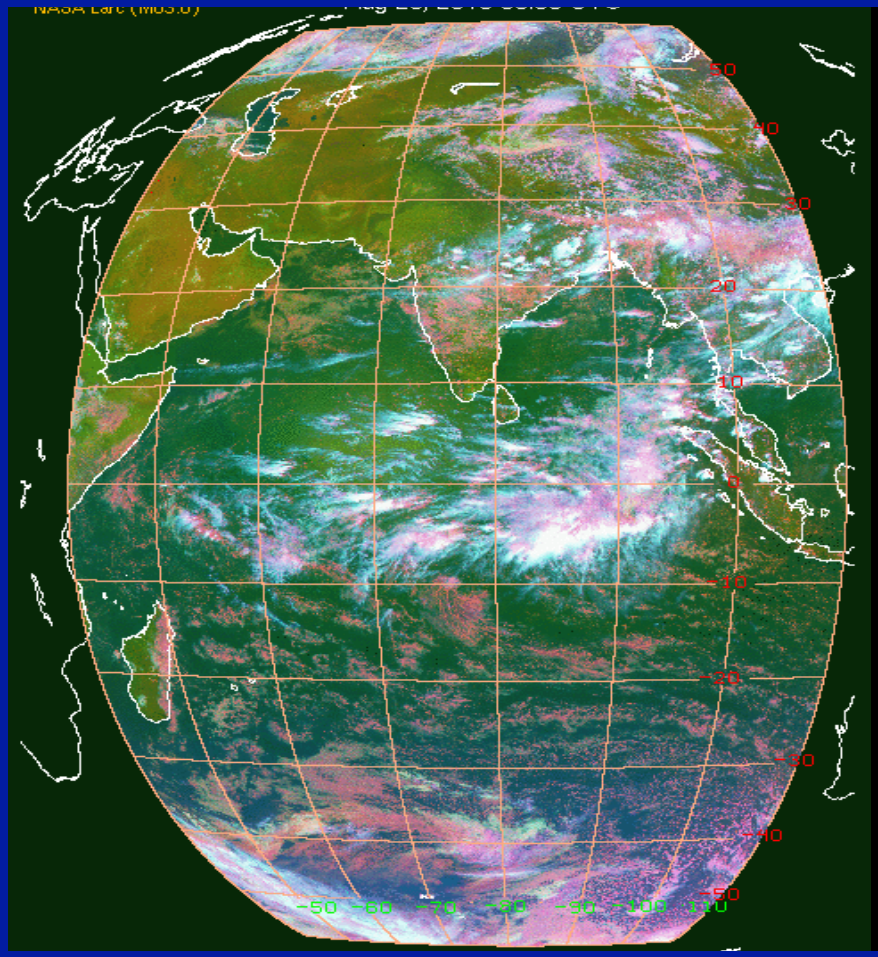


- GEO generally has larger CODs than MODIS even when using same LT
  - *resolution effects (missed thin low clouds because smearing)*

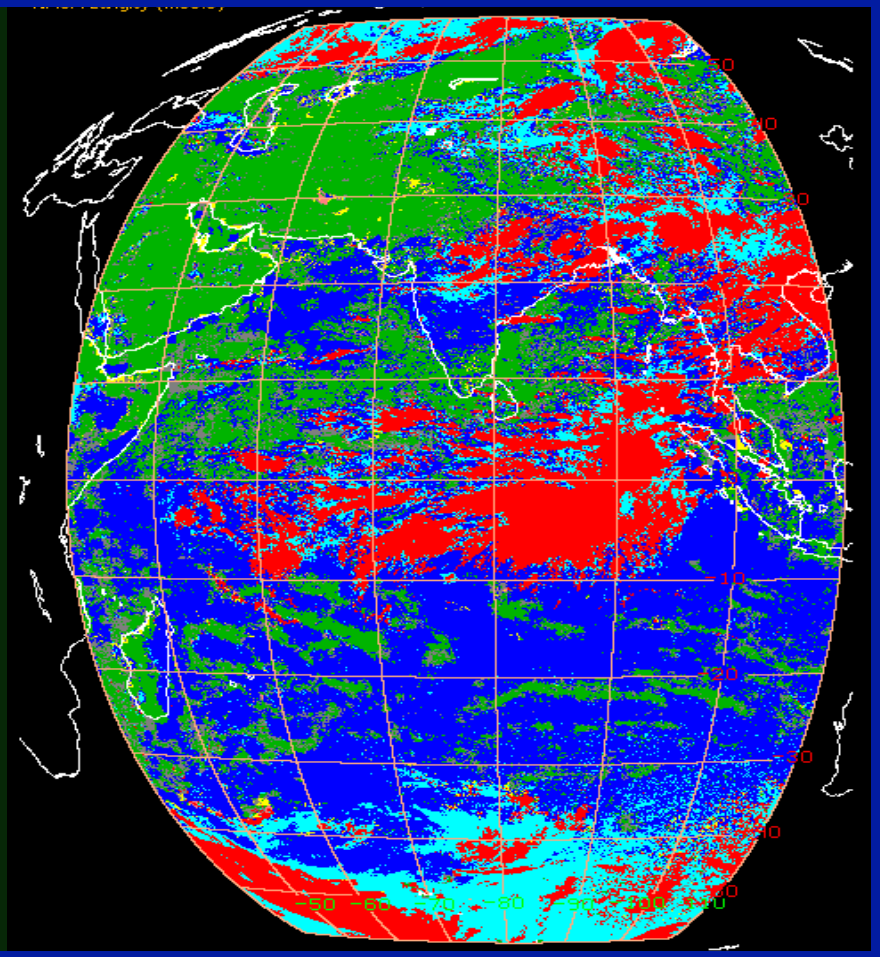
INSAT-3D Geostationary Satellite

29 August, 2015, UTC 0800 UTC

RGB



Cloud Phase

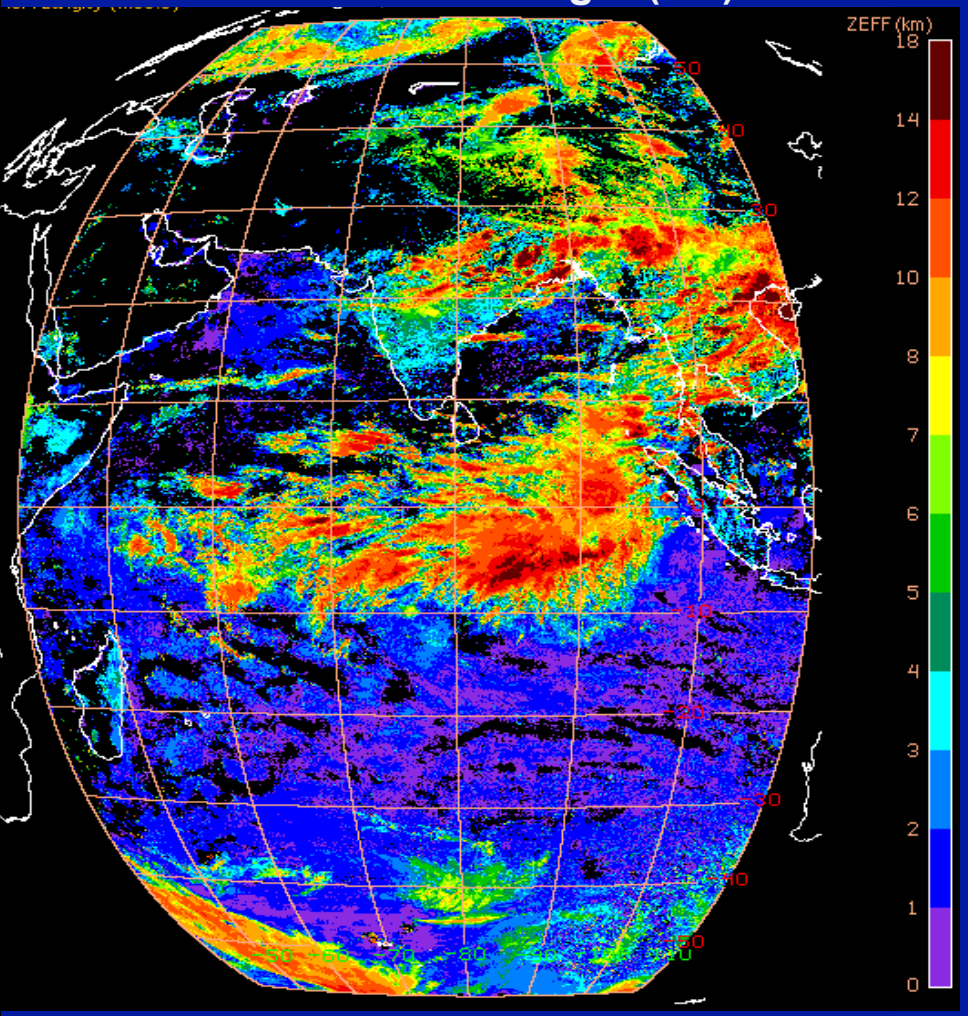


- Initial adjustments have reduced false cloud areas
  - *few more tweaks needed for daytime*
  - *infrared channels need adjustment at night*

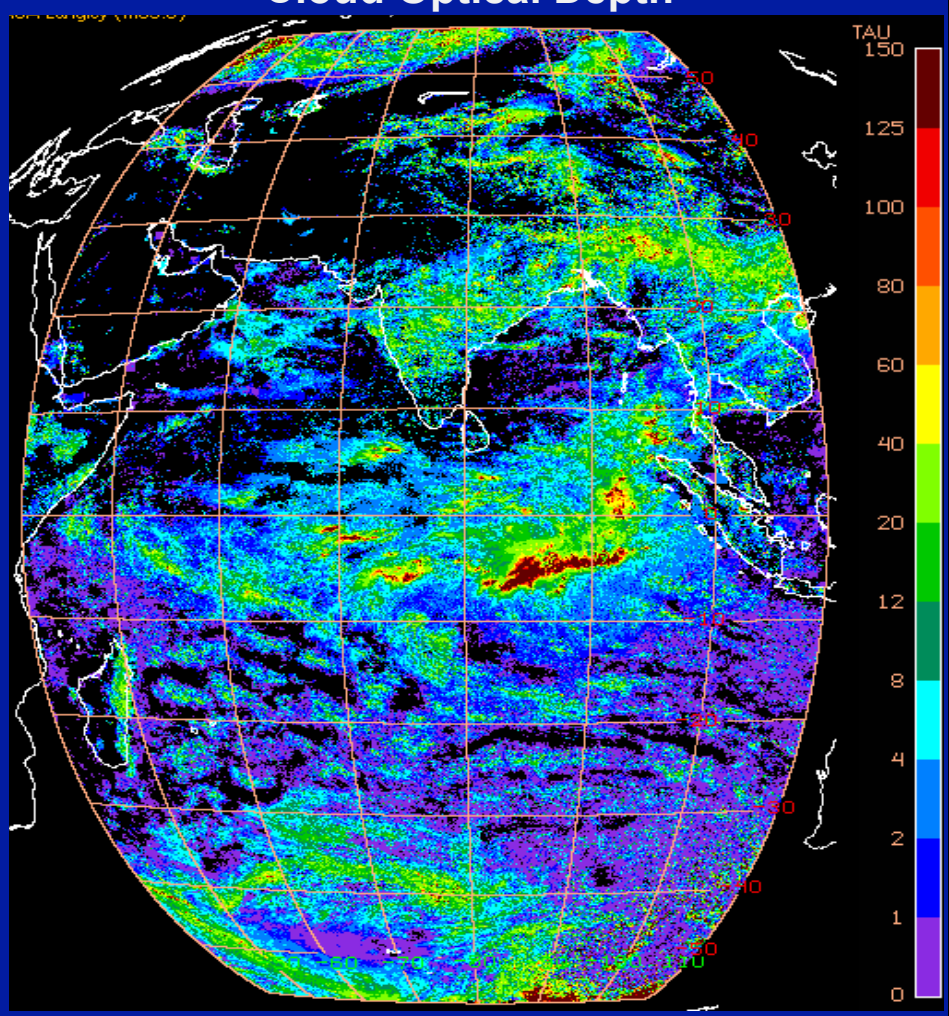
INSAT-3D Geostationary Satellite

29 August, 2015, UTC 0800 UTC

Cloud Effective Height (km)



Cloud Optical Depth

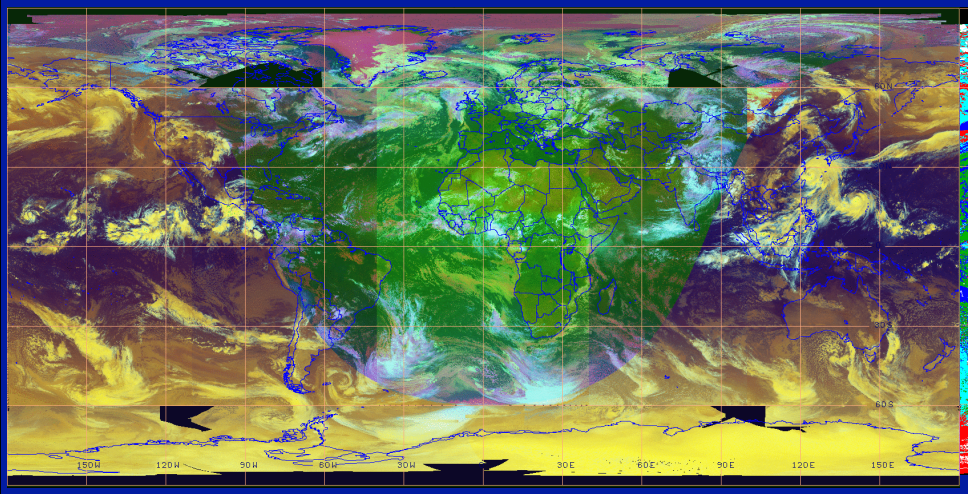


- Cloud heights and optical depths very reasonable
  - *areas of questionable cloudiness (among StCu)*
  - *marked by low altitude & small COD*

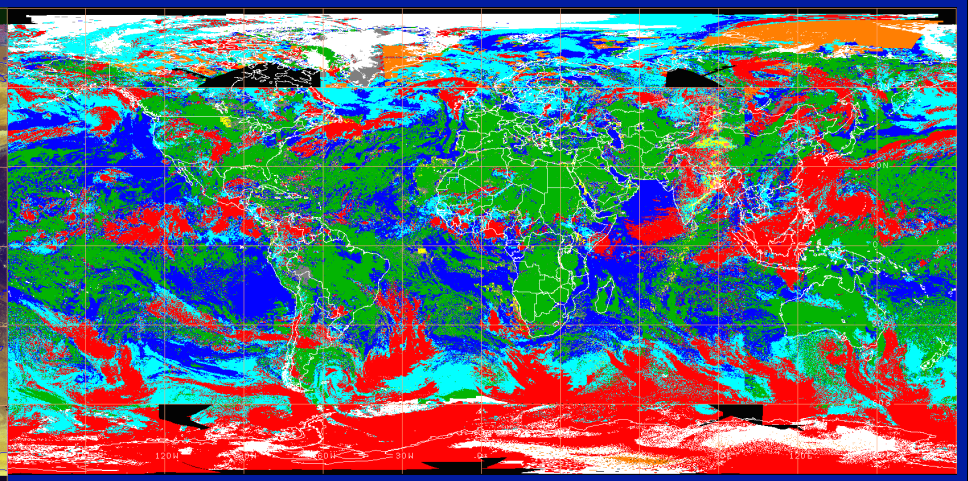
Merged Global MODIS & GEOSat Cloud Properties

0000 UTC, 13 July 2-15

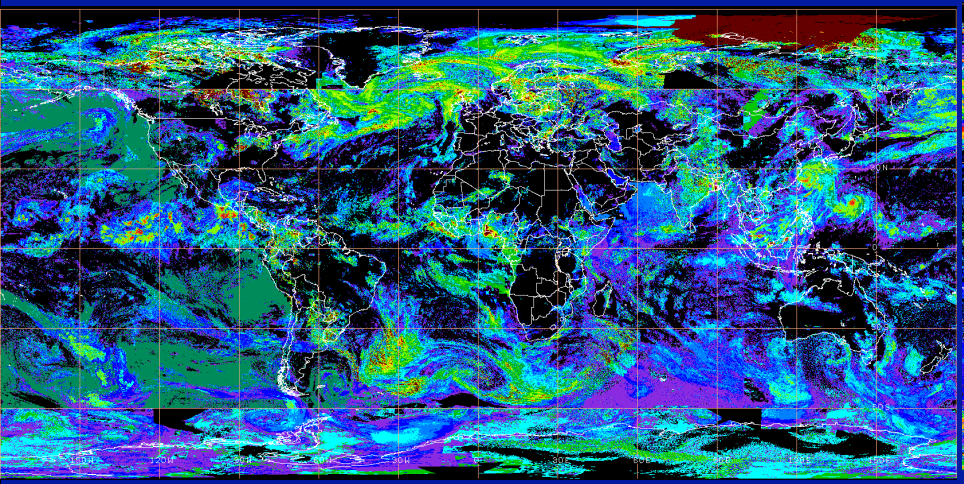
Pseudo RGB



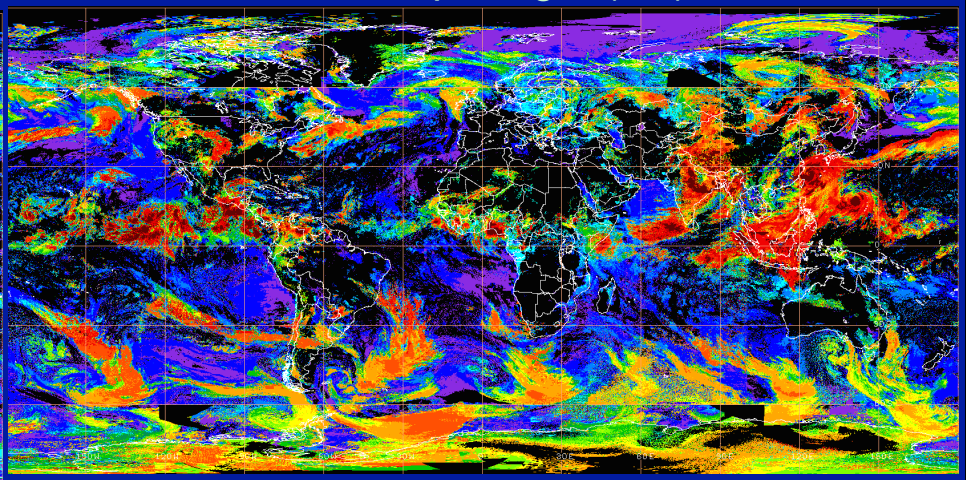
Scene Classification



Cloud Optical Depth



Cloud Top Height (km)

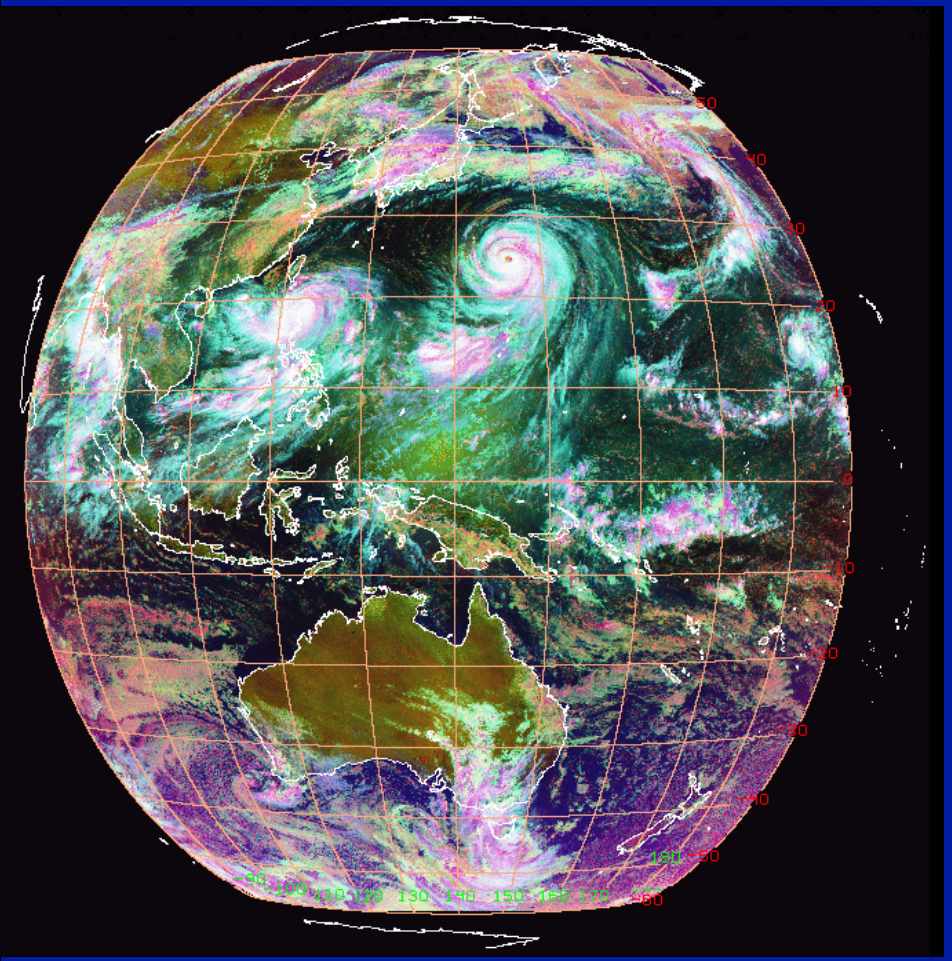


- With INSAT, full hourly coverage of 5-Ch GEOSats in nonpolar regions
- Multiple sampling in polar regions by MODIS=> ~global hourly coverage

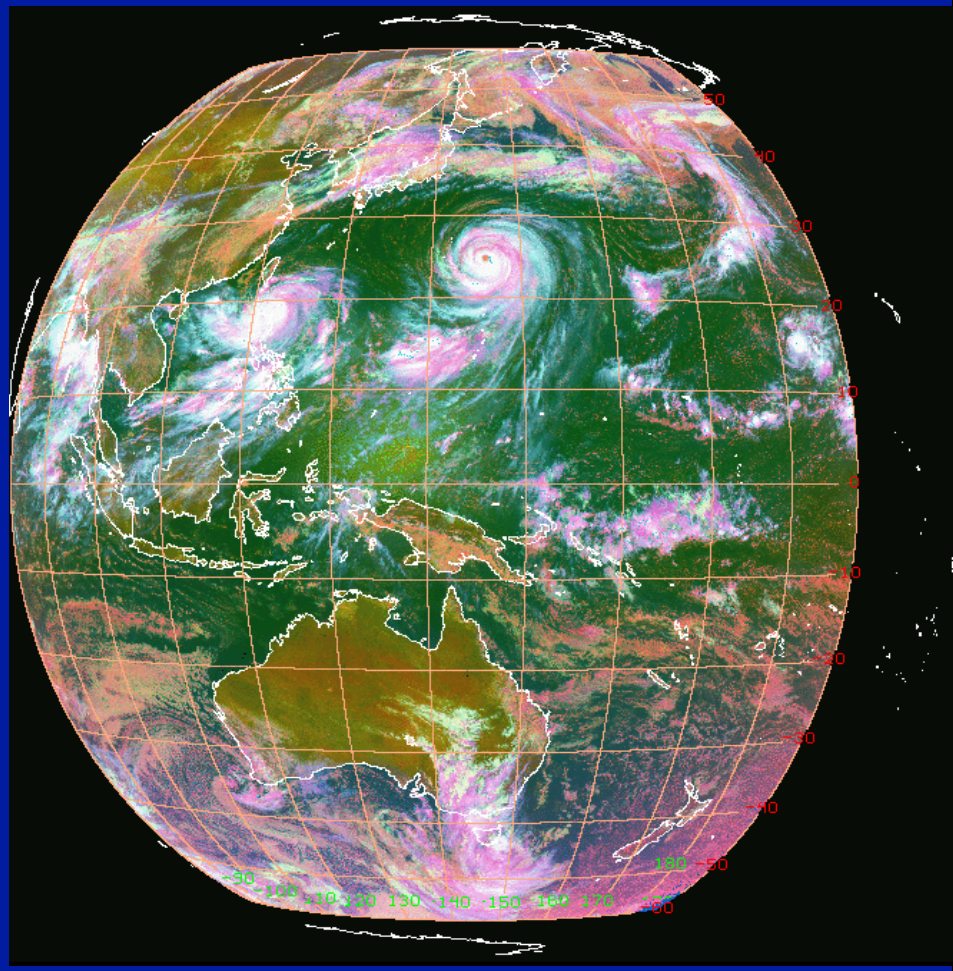
Preliminary Himwari-8 vs. MTSAT-2

0300/0330 UTC, 21 August 2015

Himawari RGB



MTSAT-2 RGB

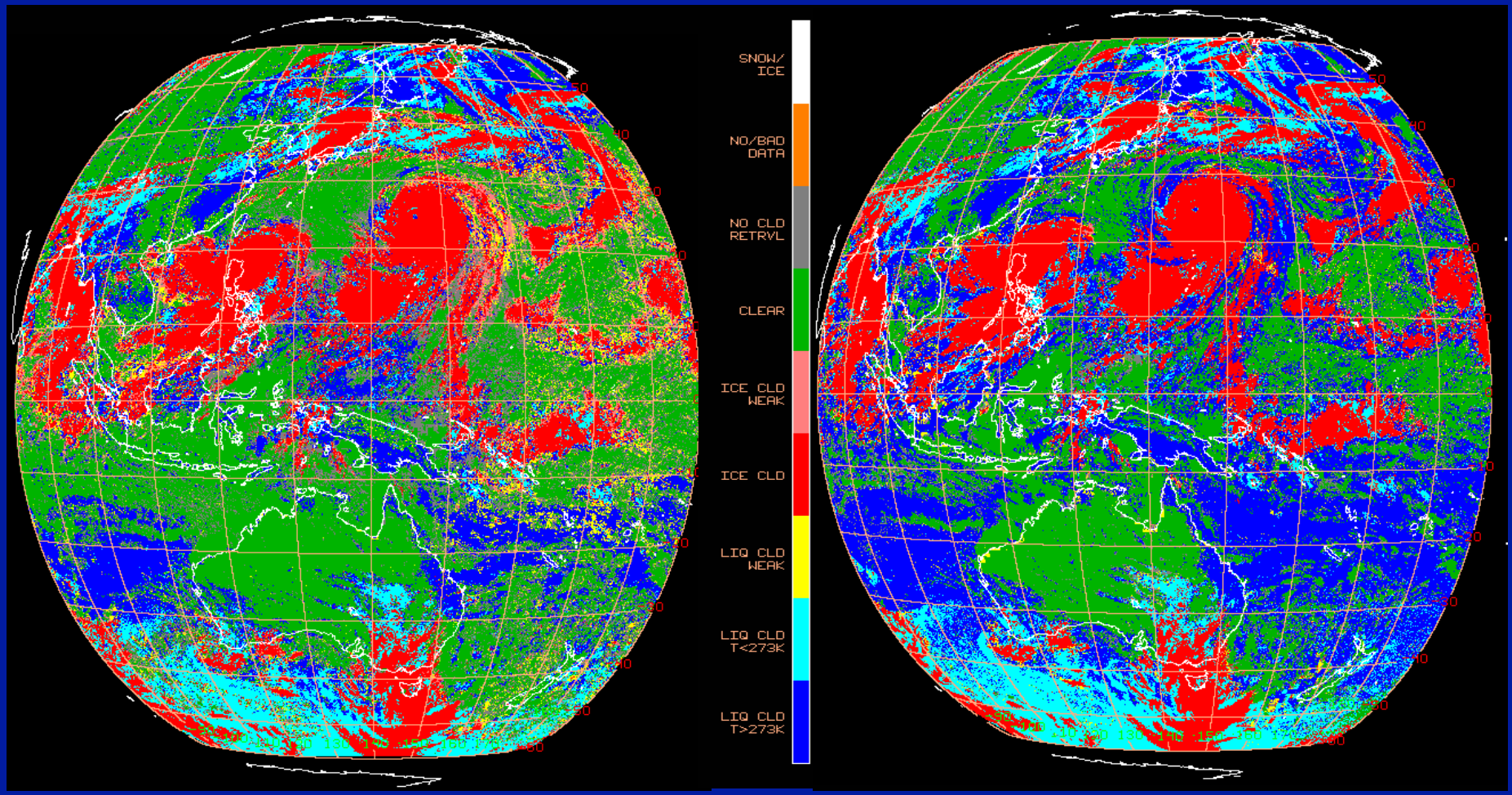


- This is equivalent to the GOES-R, but already operating
  - *have initial calibrations and running as if it were Meteosat*

Preliminary Himwari-8 vs. MTSAT-2: Cloud Phase

0300/0330 UTC, 21 August 2015

Himawari RGB | **MTSAT-2 RGB**



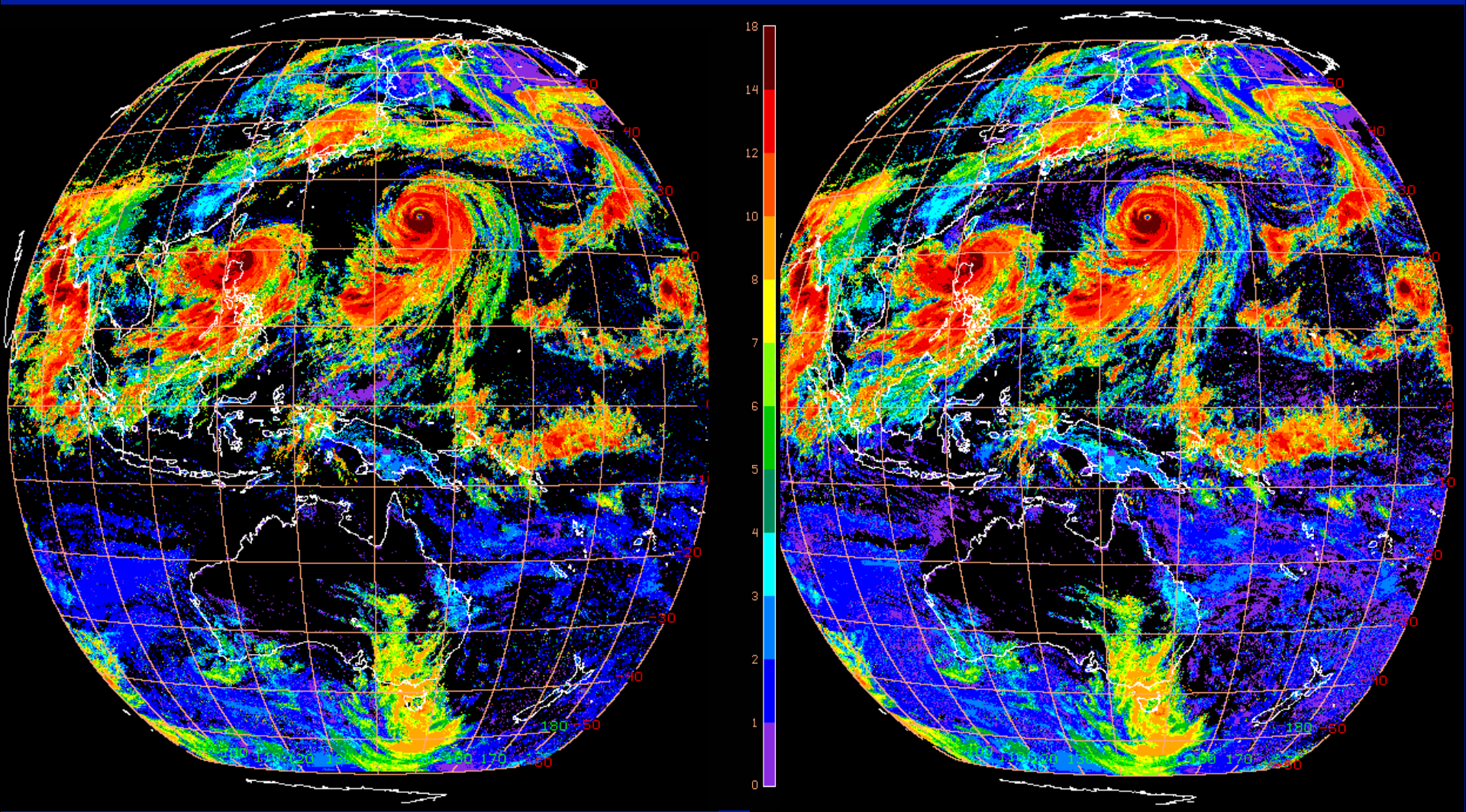
- Missing low clouds, but fewer false detections
  - *better phase detection*
  - *need evaluation of calibrations and adjustments*

Preliminary Himwari-8 vs. MTSAT-2: Cloud Eff Height

0300/0330 UTC, 21 August 2015

RGB

MTSAT-2



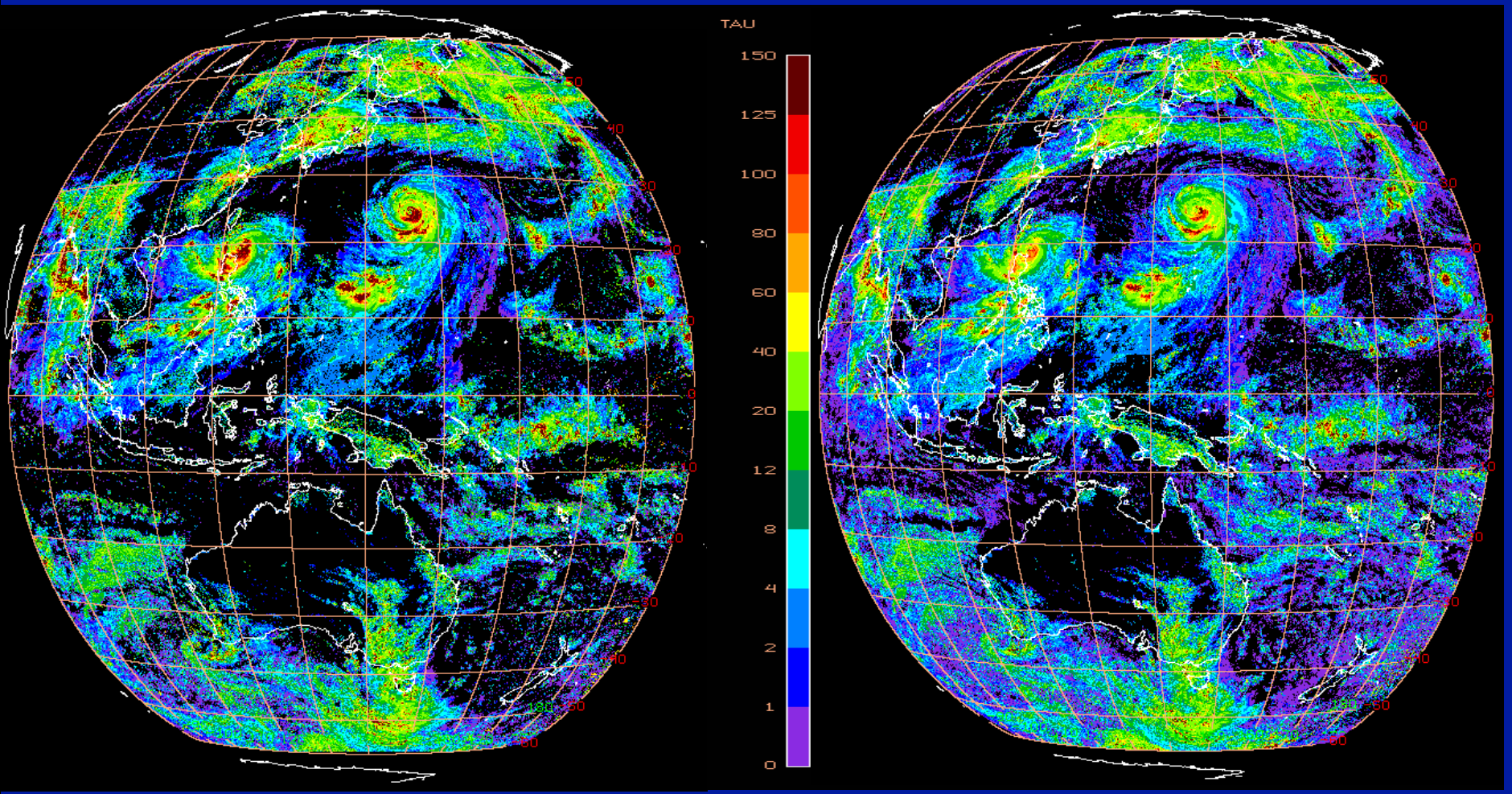
- Cloud heights close to MTSAT-2
  - *areas of water-to-ice much higher with H8*

Preliminary Himwari-8 vs. MTSAT-2: Cloud Optical Depth

0300/0330 UTC, 21 August 2015

Himiwari-8

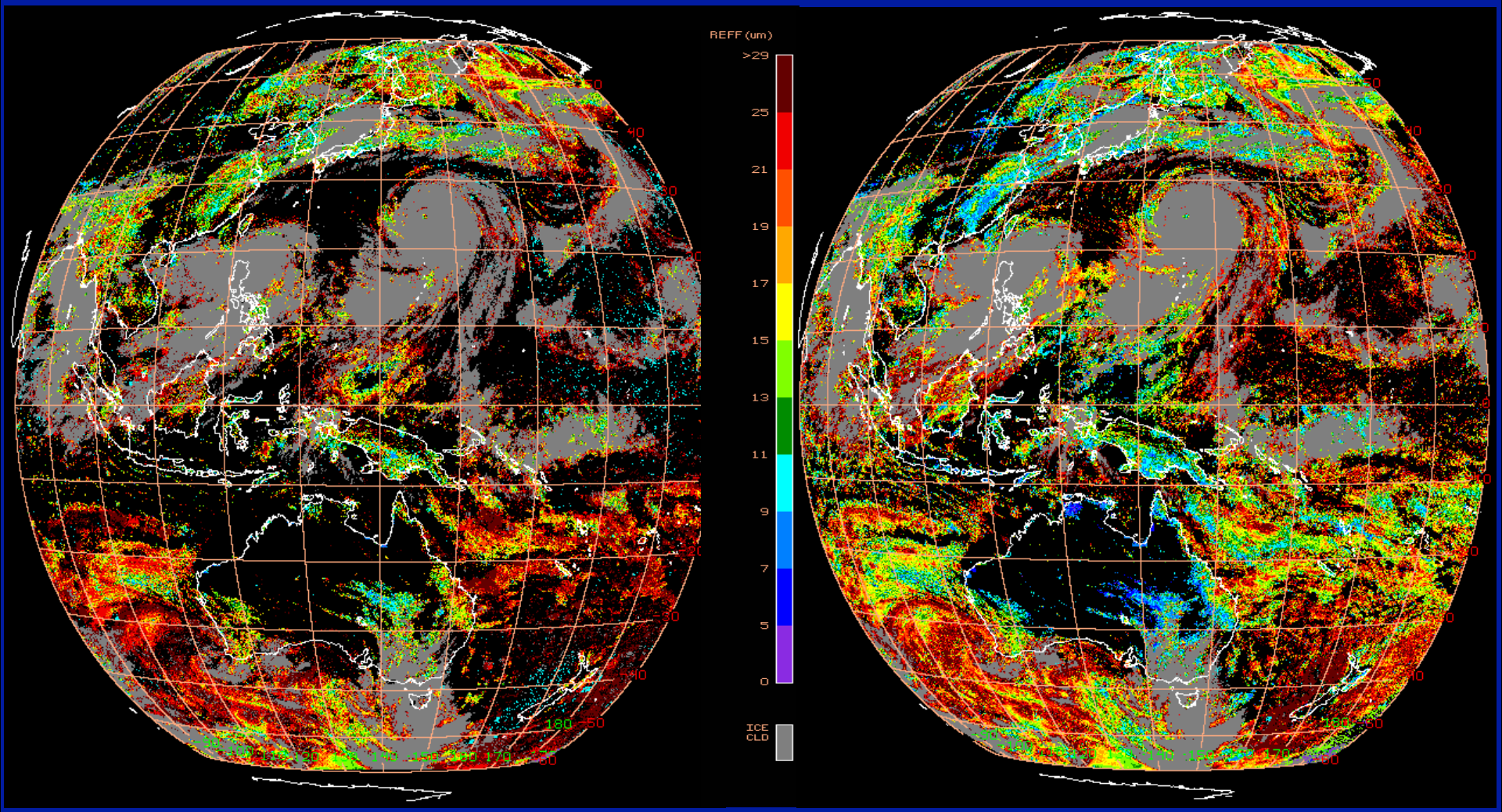
MTSAT-2



- Initial retrievals
  - *more extreme COD (high res H8)*
  - *fewer areas of low COD because of missed clouds*

Preliminary Himwari-8 vs. MTSAT-2: Water Droplet Effective Radius (μm)

0300/0330 UTC, 21 August 2015



- Patterns similar, but magnitudes different, same for ice Re
  - *H8 too large, check calibrations of 3.7 μm channel*

Toward Edition 5

- Use MODIS Collection 6 calibrations
  - *improve front end of Terra VIS and maybe later A/T VIS*
  - *remove variations in Terra 3.7 & possible 11/12-μm calibration shortcomings*

- Employ new 2-Habit model from P. Yang for ice clouds
  - testing still underway

- Revised algorithms for 1.24, 1.6, and 2.1 μm retrievals
  - *optimal multi-channel algorithm for cloud/snow retrievals*

- Improved multi-layer algorithms?

- Nighttime ice cloud optical depths from neural network

- Bug fixes

- Improved phase selections, and cloud mask

A-Train Merge Set